ANNUAL REPORT

OF

THE BOARD OF REGENTS

OF THE

SMITHSONIAN INSTITUTION,

SHOWING

THE OPERATIONS, EXPENDITURES, AND CONDITION OF THE INSTITUTION FOR THE YEAR 1867.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1872.

IN THE SENATE OF THE UNITED STATES,

May 30, 1868.

Resolved, That five thousand additional copies of the report of the Smithsonian Institution for the year eighteen hundred and sixty-seven be printed—three thousand for the use of the Senate, and two thousand for the Institution; and that said report be stereotyped: *Provided*, That the aggregate number of pages of said report shall not exceed four hundred and fifty, without illustrations except those furnished by the Institution.

IN THE HOUSE OF REPRESENTATIVES,

June 5, 1868.

Resolved, That there be printed five thousand extra copies of the report of the Smithsonian Institution—three thousand for the use of the House, and two thousand for the Institution—and that the same be stereotyped at the expense heretofore provided for.

Congress of the United States, in the House of Representatives,
Forty-second Congress, Second Session, *May* 29, 1872.

The following resolution, originating in the House of Representatives on the 23d instant, has this day been concurred in by the Senate:

Resolved, (the Senate concurring,) That two thousand extra copies each of the reports of the Smithsonian Institution, of which the stereotype-plates are now in the Congressional Printing-Office, be printed for distribution by the Smithsonian Institution to libraries, colleges, and public establishments.

Attest: EDW. McPHERSON,
Clerk.

LETTER

OF THE

SECRETARY OF THE SMITHSONIAN INSTITUTION,

COMMUNICATING

THE ANNUAL REPORT OF THE OPERATIONS, EXPENDITURES, AND CONDITION OF THE INSTITUTION FOR THE YEAR 1867.

SMITHSONIAN INSTITUTION,
Washington, May 29, 1868.

SIR: In behalf of the Board of Regents, I have the honor to submit to the Congress of the United States the annual report of the operations, expenditures, and condition of the Smithsonian Institution for the year 1867.

I have the honor to be, very respectfully, your obedient servant,

JOSEPH HENRY,
Secretary Smithsonian Institution.

Hon. B. F. WADE,
President of the Senate.

Hon. S. COLFAX,
Speaker of the House of Representatives.

ANNUAL REPORT OF THE BOARD OF REGENTS

OF THE

SMITHSONIAN INSTITUTION,

SHOWING

THE OPERATIONS, EXPENDITURES, AND CONDITION OF THE INSTITUTION FOR THE YEAR 1867.

To the Senate and House of Representatives:

In obedience to the act of Congress of August 10, 1846, establishing the Smithsonian Institution, the undersigned, in behalf of the Regents, submit to Congress, as a report of the operations, expenditures and condition of the Institution, the following documents:

1. The Annual Report of the Secretary, giving an account of the operations of the Institution during the year 1867.
2. Reports of the Executive and Building Committees.
3. Proceedings of the Board of Regents.
4. Appendix.

Respectfully submitted.

S. P. CHASE, *Chancellor.*
JOSEPH HENRY, *Secretary.*

OFFICERS OF THE SMITHSONIAN INSTITUTION.

MAY, 1868.

ANDREW JOHNSON, President of the United States, *ex officio* presiding officer of the Institution.

SALMON P. CHASE, Chancellor.

JOSEPH HENRY, Secretary.
SPENCER F. BAIRD, Assistant Secretary.
WILLIAM J. RHEES, Chief Clerk.

RICHARD WALLACH, }
RICHARD DELAFIELD, } Executive Committee.
PETER PARKER. }

REGENTS OF THE INSTITUTION.

B. F. WADE, Vice-President of the United States.
S. P. CHASE, Chief Justice of the United States.
R. WALLACH, Mayor of the city of Washington.
L. TRUMBULL, member of the Senate of the United States.
G. DAVIS, member of the Senate of the United States.
W. P. FESSENDEN, member of the Senate of the United States.
J. A. GARFIELD, member of the House of Representatives.
L. P. POLAND, member of the House of Representatives.
J. V. L. PRUYN, member of the House of Representatives.
WILLIAM B. ASTOR, citizen of New York.
THEODORE D. WOOLSEY, citizen of Connecticut.
LOUIS AGASSIZ, citizen of Massachusetts.
JOHN MACLEAN, citizen of New Jersey.
RICHARD DELAFIELD, citizen of Washington.
PETER PARKER, citizen of Washington.

MEMBERS EX-OFFICIO OF THE INSTITUTION.

ANDREW JOHNSON, President of the United States.
B. F. WADE, Vice-President of the United States.
W. H. SEWARD, Secretary of State.
H. McCULLOCH, Secretary of the Treasury.
Secretary of War.
G. WELLES, Secretary of the Navy.
A. W. RANDALL, Postmaster General.
Attorney General.
S. P. CHASE, Chief Justice of the United States.
Commissioner of Patents.
R. WALLACH, Mayor of Washington.
O. H. BROWNING,* Secretary of the Interior.

* Honorary member.

PROGRAMME OF ORGANIZATION

OF THE

SMITHSONIAN INSTITUTION.

[PRESENTED IN THE FIRST ANNUAL REPORT OF THE SECRETARY, AND ADOPTED BY THE BOARD OF REGENTS, DECEMBER 13, 1847.]

INTRODUCTION.

General considerations which should serve as a guide in adopting a Plan of Organization.

1. WILL OF SMITHSON. The property is bequeathed to the United States of America, "to found at Washington, under the name of the SMITHSONIAN INSTITUTION, an establishment for the increase and diffusion of knowledge among men."

2. The bequest is for the benefit of mankind. The government of the United States is merely a trustee to carry out the design of the testator.

3. The Institution is not a national establishment, as is frequently supposed, but the establishment of an individual, and is to bear and perpetuate his name.

4. The objects of the Institution are, 1st, to increase, and, 2d, to diffuse knowledge among men.

5. These two objects should not be confounded with one another. The first is to enlarge the existing stock of knowledge by the addition of new truths; and the second, to disseminate knowledge, thus increased, among men.

6. The will makes no restriction in favor of any particular kind of knowledge; hence all branches are entitled to a share of attention.

7. Knowledge can be increased by different methods of facilitating and promoting the discovery of new truths; and can be most extensively diffused among men by means of the press.

8. To effect the greatest amount of good, the organization should be such as to enable the Institution to produce results, in the way of increasing and diffusing knowledge, which cannot be produced either at all or so efficiently by the existing institutions in our country.

9. The organization should also be such as can be adopted provisionally; can be easily reduced to practice; receive modifications, or be abandoned, in whole or in part, without a sacrifice of the funds.

10. In order to compensate, in some measure, for the loss of time occasioned by the delay of eight years in establishing the Institution, a considerable portion of the interest which has accrued should be added to the principal.

11. In proportion to the wide field of knowledge to be cultivated, the funds are small. Economy should, therefore, be consulted in the construction of the building; and not only the first cost of the edifice should be considered, but also the continual expense of keeping it in repair, and of the support of the establishment necessarily connected with it. There should also be but few individuals permanently supported by the Institution.

12. The plan and dimensions of the building should be determined by the plan of the organization, and not the converse.

13. It should be recollected that mankind in general are to be benefited by the bequest, and that, therefore, all unnecessary expenditure on local objects would be a perversion of the trust.

14. Besides the foregoing considerations, deduced immediately from the will of Smithson, regard must be had to certain requirements of the act of Congress establishing the Institution. These are, a library, a museum, and a gallery of art, with a building on a liberal scale to contain them.

SECTION I.

Plan of organization of the Institution in accordance with the foregoing deductions from the will of Smithson.

To INCREASE KNOWLEDGE. It is proposed—

1. To stimulate men of talent to make original researches, by offering suitable rewards for memoirs containing new truths; and,

2. To appropriate annually a portion of the income for particular researches, under the direction of suitable persons.

To DIFFUSE KNOWLEDGE. It is proposed—

1. To publish a series of periodical reports on the progress of the different branches of knowledge; and,

2. To publish occasionally separate treatises on subjects of general interest.

DETAILS OF THE PLAN TO INCREASE KNOWLEDGE.

I. *By stimulating researches.*

1. Facilities afforded for the production of original memoirs on all branches of knowledge.

2. The memoirs thus obtained to be published in a series of volumes, in a quarto form, and entitled Smithsonian Contributions to Knowledge.

3. No memoir on subjects of physical science to be accepted for publication which does not furnish a positive addition to human

knowledge, resting on original research; and all unverified speculations to be rejected.

4. Each memoir presented to the Institution to be submitted for examination to a commission of persons of reputation for learning in the branch to which the memoir pertains; and to be accepted for publication only in case the report of this commission is favorable.

5. The commission to be chosen by the officers of the Institution, and the name of the author, as far as practicable, concealed, unless a favorable decision is made.

6. The volumes of the memoirs to be exchanged for the transactions of literary and scientific societies, and copies to be given to all the colleges and principal libraries in this country. One part of the remaining copies may be offered for sale, and the other carefully preserved, to form complete sets of the work, to supply the demand from new institutions.

7. An abstract, or popular account, of the contents of these memoirs to be given to the public through the annual report of the Regents to Congress.

II. *By appropriating a part of the income, annually, to special objects of research, under the direction of suitable persons.*

1. The objects and the amount appropriated, to be recommended by counsellors of the Institution.

2. Appropriations in different years to different objects; so that in course of time each branch of knowledge may receive a share.

3. The results obtained from these appropriations to be published, with the memoirs before mentioned, in the volumes of the Smithsonian Contributions to Knowledge.

4. Examples of objects for which appropriations may be made.

(1.) System of extended meteorological observations for solving the problem of American storms.

(2.) Explorations in descriptive natural history, and geological, magnetical, and topographical surveys, to collect materials for the formation of a Physical Atlas of the United States.

(3.) Solution of experimental problems, such as a new determination of the weight of the earth, of the velocity of electricity, and of light; chemical analyses of soils and plants; collection and publication of scientific facts accumulated in the offices of government.

(4.) Institution of statistical inquiries with reference to physical, moral, and political subjects.

(5.) Historical researches, and accurate surveys of places celebrated in American history.

(6.) Ethnological researches, particularly with reference to the different races of men in North America; also, explorations and accurate surveys of the mounds and other remains of the ancient people of our country.

DETAILS OF THE PLAN FOR DIFFUSING KNOWLEDGE.

I. *By the publication of a series of reports, giving an account of the new discoveries in science, and of the changes made from year to year in all branches of knowledge not strictly professional.*

1. These reports will diffuse a kind of knowledge generally interesting, but which, at present, is inaccessible to the public. Some of the reports may be published annually, others at longer intervals, as the income of the Institution or the changes in the branches of knowledge may indicate.

2. The reports are to be prepared by collaborators eminent in the different branches of knowledge.

3. Each collaborator to be furnished with the journals and publications, domestic and foreign, necessary to the compilation of his report; to be paid a certain sum for his labors, and to be named on the title-page of the report.

4. The reports to be published in separate parts, so that persons interested in a particular branch can procure the parts relating to it without purchasing the whole.

5. These reports may be presented to Congress, for partial distribution, the remaining copies to be given to literary and scientific institutions, and sold to individuals for a moderate price.

The following are some of the subjects which may be embraced in the reports:*

I. PHYSICAL CLASS.

1. Physics, including astronomy, natural philosophy, chemistry, and meteorology.
2. Natural history, including botany, zoology, geology, &c.
3. Agriculture.
4. Application of science to arts.

II. MORAL AND POLITICAL CLASS.

5. Ethnology, including particular history, comparative philology, antiquities, &c.
6. Statistics and political economy.
7. Mental and moral philosophy.
8. A survey of the political events of the world; penal reform, &c.

III. LITERATURE AND THE FINE ARTS.

9. Modern literature.
10. The fine arts, and their application to the useful arts.
11. Bibliography.
12. Obituary notices of distinguished individuals.

II. *By the publication of separate treatises on subjects of general interest.*

1. These treatises may occasionally consist of valuable memoirs translated from foreign languages, or of articles prepared under the

* This part of the plan has been but partially carried out.

direction of the Institution, or procured by offering premiums for the best exposition of a given subject.

2. The treatises should, in all cases, be submitted to a commission of competent judges, previous to their publication.

3. As examples of these treatises, expositions may be obtained of the present state of the several branches of knowledge mentioned in the table of reports.

SECTION II.

Plan of organization, in accordance with the terms of the resolutions of the Board of Regents providing for the two modes of increasing and diffusing knowledge.

1. The act of Congress establishing the Institution contemplated the formation of a library and a museum; and the Board of Regents, including these objects in the plan of organization, resolved to divide the income* into two equal parts.

2. One part to be appropriated to increase and diffuse knowledge by means of publications and researches, agreeably to the scheme before given. The other part to be appropriated to the formation of a library and a collection of objects of nature and of art.

3. These two plans are not incompatible with one another.

4. To carry out the plan before described, a library will be required, consisting, 1st, of a complete collection of the transactions and proceedings of all the learned societies in the world; 2d, of the more important current periodical publications, and other works necessary in preparing the periodical reports.

5. The Institution should make special collections, particularly of objects to illustrate and verify its own publications.

6. Also, a collection of instruments of research in all branches of experimental science.

7. With reference to the collection of books, other than those mentioned above, catalogues of all the different libraries in the United States should be procured, in order that the valuable books first purchased may be such as are not to be found in the United States.

8. Also, catalogues of memoirs, and of books and other materials, should be collected for rendering the Institution a centre of bibliographical knowledge, whence the student may be directed to any work which he may require.

9. It is believed that the collections in natural history will increase by donation as rapidly as the income of the Institution can make provision for their reception, and, therefore, it will seldom be necessary to purchase articles of this kind.

10. Attempts should be made to procure for the gallery of art casts of the most celebrated articles of ancient and modern sculpture.

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* The amount of the Smithsonian bequest received into the Treasury of the United States is	$515,169 00
Interest on the same to July 1, 1846, (devoted to the erection of the building)	242,129 00
Annual income from the bequest	30,910 14

11. The arts may be encouraged by providing a room, free of expense, for the exhibition of the objects of the Art-Union and other similar societies.

12. A small appropriation should annually be made for models of antiquities, such as those of the remains of ancient temples, &c.

13. For the present, or until the building is fully completed, besides the Secretary, no permanent assistant will be required, except one, to act as librarian.

14. The Secretary, by the law of Congress, is alone responsible to the Regents. He shall take charge of the building and property, keep a record of proceedings, discharge the duties of librarian and keeper of the museum, and may, with the consent of the Regents, *employ assistants.*

15. The Secretary and his assistants, during the session of Congress, will be required to illustrate new discoveries in science, and to exhibit new objects of art. Distinguished individuals should also be invited to give lectures on subjects of general interest.

This programme, which was at first adopted provisionally, has become the settled policy of the Institution The only material change is that expressed by the following resolutions, adopted January 15, 1855, viz:

Resolved, That the 7th resolution passed by the Board of Regents, on the 26th of January, 1847, requiring an equal division of the income between the active operations and the museum and library, when the buildings are completed, be, and it is hereby, repealed.

Resolved, That hereafter the annual appropriations shall be apportioned specifically among the different objects and operations of the Institution, in such manner as may, in the judgment of the Regents, be necessary and proper for each, according to its intrinsic importance and a compliance in good faith with the law.

REPORT

OF

THE SECRETARY, PROFESSOR HENRY,

FOR

1867.

To the Board of Regents of the Smithsonian Institution:

GENTLEMEN: The close of the year 1866 completed the second decade of the actual operations of the Smithsonian Institution. It was chartered in August, 1846; though but little more was accomplished during that year than a discussion of plans, and the appointment of the Secretary, the principal executive officer.

On thus commencing a new decade in the history of the Institution, we may pause a few moments to recall some facts relative to the character, the acceptance, and the administration of the endowment of Smithson, which it is important always to keep in view. This will be evident when we reflect on the changeable character of the bodies constituting the guardians of the trust. Not a single Regent on the list of those originally appointed is now a member of the board, and indeed, with perhaps one single exception, all the members of Congress and the principal officers of the general government have been changed, and in some cases many times in succession. Under these circumstances it becomes desirable that frequent reference should be had to the original principles on which the Institution was founded, as well as to those on which its affairs are now conducted.

The endowment was one of no ordinary character; it was confided to our government not by one of its own citizens, but by a distinguished foreigner, the scion of an ancient house renowned for its achievements in English history. It was not given in trust to our government to be disposed of for the exclusive benefit of a portion of our own people, or even for that of the whole nation, but in behalf of the general family of mankind, for the benefit of men of all coun-

tries and of all times. It was not restricted in effect to the diffusion of a knowledge of old truths, but primarily designed for the extension of the boundaries of thought by the promotion of the discovery of new powers of nature, of new principles and new laws of the universe. Nor was the acceptance of the trust an ordinary occurrence. It became a constitutional question whether the Congress of the United States was legally authorized to assume the responsibility and discharge the duty of a trustee for such a purpose; nor was it until after the expression of many doubts as to the result, that the acceptance was finally resolved on. Again, one of our most distinguished citizens, Hon. Richard Rush, who had previously represented our government at the court of St. James, was chosen as the agent to effect a transfer of the funds to this country, and this he was enabled to do without the delay of protracted legal proceedings, through the courtesy of the court of chancery in granting a decree to that effect, after a mere formal suit to satisfy the requirements of law.

A trust of so novel a character, confided by a prominent citizen of England, not to his own government, but to that of the United States, could not fail to attract general attention and place in a conspicuous light before the world, the integrity, intelligence and executive ability of the party accepting an office of so much responsibility and difficulty as that of the trustee of this endowment.

The obligation became more impressive in consideration of the fact that the trust was accepted after the decease of him by whom it was confided, and who could, therefore, give no further indications of his intentions than those expressed in the terms of his will. It was, consequently, of the first importance that these terms should be critically studied, logically interpreted, and the intentions deduced from them be strictly followed. Unfortunately, however, at the time the bequest was accepted, the public at large were so little acquainted with the distinctions of science, or so little regardful of the precise ideas to be attached to the terms which it employs, that it is scarcely a matter of surprise that the intention of Smithson, as expressed by the words "for the increase and diffusion of knowledge among men" should have been misinterpreted, and that the act of Congress organizing the Institution should include provisions which have since been generally recognized as incompatible with the leading objects of the bequest.

It is, however, a sacred duty on the part of the government, which it owes to its own character for candor and equity, to correct, as far as possible, any errors which misapprehension or inad-

vertence may have engrafted on its legislation, and to remove any burdens which may have been injuriously imposed on the endowment; and we doubt not from what has been done in the last few years, that Congress will in due time fully vindicate the integrity of its purposes, and enable the legacy of Smithson to perform all the good which his most ardent desire could have anticipated.

It has been evident from the first that it was the intention of Congress to deal not only justly but liberally with the Institution. It restored the fund with interest when temporarily lost by a loan to one of the western States, and provided for its subsequent security by declaring it forever a deposit in the treasury of the United States, on which six per cent. interest, payable semi-annually, should be allowed. It furnished from the public domain grounds for a spacious park, as well as a site for a large building; and to increase, as it was thought, its popularity, the new Institution was made the custodian of the national museum. These acts, though prompted by a liberal spirit, proceeded on the erroneous idea then prevalent, that the intentions of Smithson could be properly carried out by an institution consisting of objects of a material and local character. Fortunately, however, Congress did not restrict the expenditure of the income of the fund to these, but allowed the Regents at their discretion to devote a portion of it in such other manner as in their opinion might be best fitted to carry out the intentions of the donor.

After much deliberation, with a view to reconcile conflicting opinions, an arrangement was effected by which two distinct systems were provisionally adopted. The first of these which was included in the law of organization, contemplated the expenditure of the income in the formation and embellishment of an extensive park, or pleasure ground, in which rare and ornamental trees and shrubs of different species should be cultivated; in the erection and maintenance of a castellated building, which, from its dimensions and imposing architectural design, should be an ornament to the city and a monument to the founder; in the formation of a gallery of art in which should be exhibited choice specimens of painting, sculpture and engraving; in the establishment of a library consisting of works on all subjects; and, finally, in the support of a national museum containing the collections of the United States Exploring Expedition, and all the specimens that might be accumulated from other sources for the illustration of all branches of natural history, geology, ethnology, etc.

The objects included in this system are all in themselves highly interesting and very desirable for the embellishment and intellectual improvement of the capital of the United States, but they are not in

accordance with the will of Smithson, and fail entirely to realize his higher and more comprehensive conceptions. They do not serve to "increase knowledge," or, in other words, to add new truths to the existing stock; nor do they "diffuse knowledge among men," since they are local in character, and fail to promote the general welfare of mankind. Neither could they all be properly supported from the limited income of the Smithson bequest. A library, and more especially a museum, worthy of the nation, would, either of them, in time, absorb the whole of the annual income.

The other system, above referred to, or that which has been denominated the system of active operations, was suggested by the desire to strictly realize the intentions of Smithson, both as regards the increase and the diffusion of knowledge; and this it was proposed to effect by instituting experiments or researches in all departments of science; by making explorations relative to geology, natural history, ethnology, and meteorology, and by diffusing an account of the results of all these, through the press, to every quarter of the globe. It further includes in its design the collection and labelling of large numbers of duplicate specimens, to illustrate the branches above mentioned, not merely to be deposited in a national museum, but, also, to be distributed to colleges, academies, and other establishments, for educational purposes; and, lastly, embraces in its plan an extended arrangement for international exchanges, through which the discoveries of science and the products of literature of the old and new worlds, become the common elements of intellectual progress. This system, which is immediately suggested to those familiar with scientific language, by the terms of the bequest, is a living, active organization, calculated to produce, unceasingly, results of which the value will everywhere be known and be properly appreciated. It was not, however, adopted, even provisionally, as a prominent feature of the organization without strenuous opposition, particularly on the part of the advocates of the proposition to apply the Smithson endowment to found a national library. Indeed the ideas which it involved were in advance of the times. That an institution could be established which might have an important bearing on the welfare of the world without the adventitious aid of palpable objects, was not generally comprehended.

But though restricted in its operations by limited resources and subjected to popular opposition, the system has proved in its operation to be eminently practical, and has established for the Institution a reputation as wide as civilization itself. It has connected the name of Smithson with the progress of almost every branch of science, and

has thus furnished the means of perpetuating his memory far more effectually than could be done by architectural or other local monuments, however ample in dimensions or comprehensive in design.

Instead of being, as has been supposed, adverse or neutral as regards the interests of the city of Washington, it has given it a reputation as a centre of scientific operations, and has led to a series of improvements which, in time, cannot do otherwise than promote its renown and add to its prosperity. It does not oppose an antagonism to the local objects before mentioned, but seeks to establish them on a more liberal scale by other instrumentalities. While it has distributed its publications and specimens with unprecedented liberality, it has been fully repaid with articles of a similar character. Through its exchanges it has collected a library of scientific reference superior to any in this country, and equal to any which can be found abroad. As soon as Congress shall furnish the means of supporting a national museum, it will supply this with all the foreign and domestic specimens necessary for comparison and illustration.

The two systems, at first carried on harmoniously, though in a limited way and not without mutual embarrassment, were soon found in practice to be radically incompatible with each other. As it was impossible suitably to control the expenditure on the local objects, it has been the constant policy of the Directory of the Institution to obtain relief from these burdens. It was in accordance with this that the government was solicited to resume the care of the grounds, on which had been expended annually a considerable portion of the income, and to make these grounds part of a general park extending from the Capitol to the Potomac. It was for this purpose that the Institution was instrumental in procuring the services of Mr. Downing, whose plan of the grounds in question would have been completed had not the work been interrupted by his untimely death. This work, we trust, will soon be resumed under more favorable auspices.

It was also in accordance with the policy under consideration that the valuable library which, from its rapid increase by exchanges, had already exceeded the means at the disposal of the Institution for its support, was incorporated with that of Congress.

Happily the necessity for supporting a gallery of art has been obviated by the enlightened munificence of a citizen of Washington, W. W. Corcoran, esq., who has erected a building and made provision for the support of such an establishment to which the collections in this department already formed by the Institution may be transferred.

The next important desideratum is the relief of the fund of Smithson from the greatest of all the burdens which have been imposed upon it, that, namely, of the expense involved in the care and exhibition of the national museum. For carrying on the active operations a building not to exceed a cost of seventy-five thousand dollars would have been amply sufficient, both in regard to the accommodations necessarily required and the architectural embellishments which might be thought requisite for such a structure; while the present building, the erection of which was especially urged on the ground of the necessity of providing accommodations on a liberal scale for a national museum and library, has cost to the present time $450,000, or, in other words, besides the $240,000 of accrued interest originally appropriated to the building, an outlay of not less than ten thousand dollars annually for twenty years has been devoted to the same purpose, and this expenditure must, without the relief desired, be not only continued but increased for years to come.

Though great advances have been made in the favor with which the Institution is regarded by the public, and the increased facilities which have been afforded by the transfer of the objects we have mentioned to the care of government, yet the absorption of the income by the museum and the building is so great and accelerative that unless Congress, in justice to the trust, takes upon itself the charge of these objects or provides for their maintenance the active operations must be greatly diminished in efficiency, if not ultimately abandoned. The reputation of the Institution and of the country is however too much involved in the continuance of the active operations to allow them to be abolished or even restricted. Every academy, every college, every lyceum in the United States, as well as all the literary and scientific institutions of Europe, Asia, and even those of Africa and Australia, are interested in the continued success of the system. Furthermore, it be truly said that to devolve the care of a national museum on the Smithson fund is not only an act of injustice to the bequest, but is at once injurious to the reputation of the institution and that of the government, since the means which the former can devote to this purpose after defraying other expenses are entirely inadequate to the support of a museum entitled to the name of "national." A public museum, properly organized as a means of popular education, or as an aid to the advancement of science, should not only be furnished with extensive apartments for the proper accommodation and exhibition of the articles, to be increased from time to time, but it should also be provided with several professors, each learned in a special branch of general natural history. So extended have these

departments of science become that no one individual can be profoundly acquainted with more than one or two of them; hence, in order that a director should properly perform the duties of a curator of an establishment of this kind, he should have a corps of learned assistants. For example, for the preservation and practical use of an herbarium, the constant attendance and supervision of a botanist is requisite, whose duty it will be to classify the specimens, to render them unassailable by insects, to arrange them for study or exhibition, and to be always present to assist those who may desire to examine them, either for elementary study or original research. Without a number of assistants in the line of natural history, a museum must principally consist of mere articles of curiosity, of comparatively little use in the way of valuable instruction. It is evident, however, that a corps of such assistants, supported on permanent salaries, in addition to the other expenses of the museum, would soon absorb the whole of the Smithson income.

What has been said has reference merely to the impropriety of attempting to maintain a museum worthy of the nation at the expense of the Smithson fund, and is not intended to disparage the value of a complete representation of the natural products of America, with such foreign specimens as may be required for comparison and generalization. This we think of great importance, particularly as a means of developing and illustrating our industrial resources, as well as of facilitating the study of the relations of our geology, mineralogy, flora and fauna to those of the old world; and, indeed, the wants of the government appear to demand a collection of this kind, since the Medical Department, the Agricultural Department, and the General Land Office are each rapidly accumulating articles of illustration, and find the necessity for the permanent employment of persons well skilled in the branches to which their specimens pertain. With these the national museum, of a general character, would maintain relations of co-operation and mutual assistance.

It will be seen in previous reports, that from the first, in order to compensate in some degree for the great outlay on local objects, measures were adopted for the increase of the capital of the endowment. These principally consisted in deferring the completion of the building for a series of years, and in the meanwhile investing the money appropriated for its construction, as well as a portion of the annual income, saved by judicious and economical management, in government and State stocks. These stocks, however, were not permanently secured, and were in danger of being disposed of injudiciously, upon casual or inadequate considerations. It has, there-

fore, been a matter of solicitude to obtain for them a permanent investment.

In view of this, a petition was presented to Congress by the board of regents, asking permission to make additions to the principal of the Smithson fund. This petition was granted by the act of February 8, 1867, allowing the regents to increase the principal in the treasury of the United States, by savings, donations, and otherwise, to any sum not exceeding a million dollars, the additions to be subject to the same conditions as the original bequest. In accordance with this law the regents authorized the sale of all the stocks owned by the Institution, excepting those of Virginia, and the application of the proceeds to the increase of the principal to $650,000, which amount is now the permanent fund of the Institution. In addition to this the Institution has $72,500 in Virginia State bonds, the marketable value of which is about $30,000.

The fund first paid into the treasury from the Smithson bequest was $515,169; the remainder of the legacy, which had been left in England as the principal of an annuity to the mother of the nephew of Smithson, was $26,210 63, making in all, from the bequest of Smithson, $541,379 63. The capital has, therefore, been increased more than a hundred thousand dollars, notwithstanding the expenditure of $450,000 on the building.

It will be seen by the reports of the building committee and architect, that the main building of the Institution, which consists of a large central edifice, 200 feet long, 50 feet wide, with two projecting towers and a middle space in front, and a single large tower in the rear, to which portions the damage by fire was principally confined, will be entirely restored in the course of a few months, with the exception of the large hall in the second story. These parts of the building, in which it is proposed to deposit the more valuable collections, are entirely of fire-proof materials. The cost of this reconstruction will amount to $125,000, exclusive of that of the fitting up of the large room just mentioned. The accommodations which will be afforded are amply sufficient for the active operations of the Institution for all coming time, and also for the museum, provided but few additions be made to the number of specimens exhibited; but if the increase be continued—and it is almost impossible to prevent, even if desired, the growth of an establishment of this kind—the completion of the main hall and the fitting it up with cases will become necessary, at an expense of at least $50,000. The other parts of the building, namely, the two wings and connecting ranges, with six towers, will

also require, in time, for rendering them fire-proof, a further cost of not less than $50,000.

The question then occurs, from what sources are the funds necessary for this purpose to be derived? Fortunately the permanent capital of the Institution is now secure and cannot be expended. The income, however, which, in justice and good faith, ought to be applied to the "increase and diffusion of knowledge among men," should not be mortgaged, as it were, for years to come, in providing accommodations for the government collections. Surely the intelligence of the general public and the moral sense of the community will justify Congress in making seperate provision, on a proper scale, for the support and extension of a government museum.

The large drafts upon the income since the fire and the high prices of labor and materials have interfered with as vigorous a prosecution of the active operations as was exemplified in previous years, and have induced us to discontinue some enterprises in which we were engaged, and to postpone others until a more favorable opportunity. It will be seen, however, by the following report of the operations of the Institution for the past year that much has been accomplished in the way of sustaining and advancing the reputation of the establishment:

Publications.—The greater part of the expenditures on publications during the past year has been for the printing and paper of an edition from the stereotype plates of volume XIV of the Contributions to Knowledge, and volumes VI and VII of the Miscellaneous Collections. These volumes had been published in previous years in a sufficient number of copies to supply foreign exchanges, but owing to the large demands on the income of the funds on account of the repair of the building, we were unable at the time to distribute copies to American libraries. The edition which has now been printed will, however, serve to make up all our deficiencies in this respect.

The articles contained in volume XIV of the Contributions are:

1. Discussion of the Magnetic and Meteorological Observations made at the Girard College, Philadelphia, by Prof. A. D. Bache. Parts 7–12.

2. On the Construction of a Silvered-glass Telescope, fifteen and a half inches in aperture, and its use in Celestial Photography, by Prof. Henry Draper.

3. Palæontology of the Upper Missouri, by F. B. Meek and F. V. Hayden. Part 1.

4. Cretaceous Reptiles of the United States, by Dr. Joseph Leidy.

The contents of volume VI of the Miscellaneous Collections are:

1. Monograph of the Diptera of North America, by H. Loew. Edited by Baron R. Ostensacken. Parts 1 and 2.

2. List of the Coleoptera of North America, by Dr. Jno. L. Le Conte. Part 1.

3. New Species of North American Coleoptera, by Dr. Jno. L. Le Conte.

Volume VII, Miscellaneous Collections, contains:

1. Monograph of the Bats of North America, by H. Allen, M. D.

2. Land and Fresh-water Shells of North America. Part 2. Pulmonata, Limnophila, and Thalassophila, by W. G. Binney.

3. Land and Fresh-water Shells of North America. Part 3. Ampullariidæ, Valvatidæ, Viviparidæ, Fresh-water Rissoidæ, Cyclophoridæ, Truncatellidæ, Fresh-water Neritidæ, Helicinidæ. By W. G. Binney.

4. Researches upon the Hydrobiinæ and allied forms. By Dr. Wm. Stimpson.

5. Monograph of American Corbiculadæ, recent and fossil. By Temple Prime.

6. Check-list of the Invertebrate Fossils of North America, Eocene and Oligocene. By T. A. Conrad.

7. Check-list of Fossils, Miocene. By F. B. Meek.

8. Check-list of Fossils, Cretaceous and Jurassic. By F. B. Meek.

9. Catalogue of Minerals, with their formulas, etc. By T. Egleston.

10. Dictionary of the Chinook Jargon or Trade Language of Oregon. By Geo. Gibbs.

11. Instructions for Research relative to the Ethnology and Philology of America. By Geo. Gibbs.

12. List of Works published by the Smithsonian Institution.

Of the two works mentioned in the last report as being in the press, the first, entitled "Astronomical, Magnetic, Tidal, and Meteorological Observations within the Arctic Circle, by Isaac I. Hayes, M. D.," has been completed and a small edition printed. A full description of this paper was given in the report for 1865. It forms a quarto volume of 283 pages, illustrated with six charts and fifteen wood-cuts. The principal chart shows the discoveries, tracks and surveys of the Arctic expedition of 1860 and 1861, projected on a scale of 1 to 1,200,000. Another chart shows the vicinity of Port Foulke, the winter-quarters in 1860 and 1861 of the

expedition, projected on a scale of 1 to 170,000; a third gives the Iso-magnetic lines in the vicinity of Smith's strait, and three other plates illustrate the series of tides at Port Foulke.

The second work published during the year is "Results of Meteorological Observations made at Brunswick, Maine, between 1807 and 1859, by Parker Cleaveland, L.L.D., Professor in Bowdoin College." Another quarto work in press, and nearly ready for distribution, is entitled: "Results of Meteorological Observations made at Marietta, Ohio, between 1826 and 1859, inclusive, by S. P. Hildreth, M. D.; to which are added, results of observations at Marietta, by Mr. Joseph Wood, between 1817 and 1823," which have been reduced and discussed at the expense of the Institution, by Charles A. Schott. For an account of these works see the part of this report relative to meteorology.

Additional copies of the following works have been printed during the year from the stereotype plates: Draper's Telescope; Whittlesey's Drift; Meek's Check list of Fossils; Catalogue of Birds; Chinook Jargon; List of Coleoptera; Review of American Birds; List of Publications; List of Foreign Correspondents.

The following are the rules of distribution of the Smithsonian publications:

1. They are presented to all learned societies of the first class which publish transactions, and give copies of these, in exchange, to the Institution.

2. To all foreign libraries, of the first class, provided they give in exchange their catalogues and other publications, or an equivalent, from their duplicate volumes.

3. To permanently endowed colleges in actual operation in this country, provided they furnish in return meteorological observations, catalogues of their libraries and of their students, and all other publications issued by them relative to their organization and history.

4. To all States and Territories, provided they give in return copies of all documents published under their authority.

5. To all incorporated public libraries in this country, not included in any of the foregoing classes, now containing 10,000 volumes, and to smaller libraries where a whole State or large district would be otherwise unsupplied.

Institutions devoted exclusively to the promotion of particular branches of knowledge receive such articles published by the Institution as relate to their objects. Portions of the series are also given to institutions of lower grade not entitled under the above rules to

the full series, and also to the meteorological correspondents of the Institution.

For the purpose of collecting materials for the preparation of a report on the present condition of school architecture, a letter was addressed to the officers of public instruction in our principal cities, requesting the use of the architectura illustrations of their most approved school-houses. This request was readily complied with, and a considerable number of wood cuts had been received, when Congress organized the Department of Education, to which it was thought proper to transfer them, with the understanding that they should be used in the report to be published under the direction of the Commissioner. The thanks of the Institution are due to Messrs. Philbrick, of Boston; Shippen, of Philadelphia; Van Bokkelen, of Baltimore; Swett, of San Francisco; Pickard, of Chicago; Randall, of New York; Brooks, of Springfield, Illinois; and Hart, of Trenton, New Jersey, for the promptness of their compliance with our request, as well as for the illustrations actually furnished.

The report for the year 1866, with the appendix, was printed by order of Congress, and the usual number of ten thousand extra copies struck off for distribution, 4,000 by the Institution and 6,000 by the members of the Senate and House of Representatives. It is believed that few, if any, of the government documents are more in demand by the public than this report, and it has become impossible to supply all who make application for it. Unless a larger number be ordered by Congress, the distribution must in future be more strictly conformable to the rules which have been adopted, viz:

1st. To colleges, libraries and societies' publishing transactions.

2d. To contributors to the library, museum or meteorological department of the Institution.

3d. To persons engaged in teaching or in special research, and to collaborators of the Institution.

The changes in the population of the country are so rapid that we cannot be guided by a permanent list. As a general rule, the distribution can only be made to those who make special application for each volume, excepting donors to the museum and meteorological observers.

The volume for 1866 contains, in addition to the report of the Secretary, giving an account of the operations, expenditures and condition of the Institution for the year, and the proceedings of the Board of Regents to February 22, 1867, the following articles:

A sketch of the services of the late Hon. W. W. Seaton, in con-

nection with the Smithsonian Institution, and some notices of his life and personal character. A memoir of Magendie, by M. Flourens, secretary of the French Academy of Sciences. A translation from the German, on the senses of taste, hearing, and sight. A lecture on the results of spectrum analysis applied to the heavenly bodies, by W. Huggins, of England. A translation from the German of an article on the external appearance of the sun's disk, and one from the French on accidental or subjective colors, by Abbé Moigno. A continuation of the series of articles, by Plateau, on the figures of equilibrium of a liquid mass withdrawn from the action of gravity. The annual report of transactions of the Society of Physics and Natural History, of Geneva. Original communications relative to the Tinneh or Chepewyan Indians, of British and Russian America, by Messrs. B. R. Ross, W. L. Hardisty, and S. Jones, of the Hudson's Bay Company, by Geo. Gibbs esq. An article on the aboriginal American migration, by F. Von Hellwald. An original paper on Indian pottery, by Chas. Rau, esq. An original article on artificial shell deposits of the United States, by Dr. D. G. Brinton. A sketch of ancient earthworks, by I. Dille, of Ohio. The pile-work antiquities of Olmutz, translated from a Vienna periodical. An account of antiquities on the banks of the Mississippi river and Lake Pepin, by Dr. L. C. Estes. Communications on a physical atlas of North America, by Geo. Gibbs, esq., and on ethnological research, by Dr. E. H. Davis, with tables of measurements, by Scherzer and Schwarz. Translation of the prize questions of the International Archæological Congress. An article on vitality, by Rev. H. H. Higgins. Instructions for collecting land and fresh-water shells, by James Lewis, esq. Instructions for collecting myriapods, phalangidæ, etc., by Dr. H. C. Wood. Notes on a plan of a research upon the atmosphere, by Professor C. M. Wetherill. An account of the cryolite of Greenland, by Messrs. Lewis and sons. Extracts from the meteorological correspondence of the Institution, with remarks by the secretary, Professor Henry. On horary variations of the barometer, by Marshal Vaillant, with note by the secretary. On the formation of ice at the bottom of rivers, by Mr. Engelhardt. An account of the earthquake in eastern Mexico on 2d January, 1866, by Dr. C. Sartorius. Statistics relative to Norwegian mountains, lakes, and the snow-line, by O. E. Dreutzer.

These articles embrace a wide range of subjects, and, with a single exception, were either prepared expressly for the Institution or translated from foreign journals not readily accessible to the American reader. The illustrations, *seventy* in number, were prepared at

the expense of the Institution. The translations continue to be made with spirit and fidelity by C. A. Alexander, A. M., of Washington, whose services in this connection for many years have been frequently referred to in previous reports.

Meteorology.—In order to advance those branches of science which depend especially upon instrumental observations, two kinds of labor are necessary; that which is devoted to the making and recording observations, and that which is expended in reducing and discussing them. The first, which frequently requires a large number of observers, as in the case of simultaneous meteorology, fortunately can be performed by persons having a limited amount of scientific training, although the precision and value of their observations are much enhanced by a critical knowledge of the principles upon which the observations depend; while the discussion and reduction require a knowledge of mathematical analysis, possessed by comparatively few; and hence it is not surprising that the accumulation of crude observations should be far in advance of their philosophic discussion, or that at the present time the great desideratum in meteorology is a full discussion, on a general plan, of all the series of observations which have been recorded. If this were properly executed, we should be prepared to commence a new era in this branch of science, and to direct attention to new points of investigation, from indications furnished by the discussions.

In consideration of this state of meteorological data we have concluded, in view of the improvement of the funds, to resume the general discussion of the material which the Institution has already accumulated. We have accordingly commenced this work by the reduction and discussion of all the observations on the *rain-fall* of the North American continent, the results of which are much called for on account of their agricultural, manufacturing, commercial, and sanitary applications. Observations from upwards of twelve hundred localities are now in the hands of the computers, and it is expected that the results will be ready for publication towards the close of 1868. After having discussed all the observations which have been previously recorded, we shall then be prepared to commence a new and more extended series relative to precipitation, and for this purpose we have had prepared a large number of measuring scales, consisting of slips of box wood graduated to the tenth of an inch, to be distributed very generally over the country, with instructions for the observation and record of rain-fall. After carefully considering the

several forms of rain gauges, we have decided to recommend the general adoption of a simple cylindrical vessel of three or four inches in diameter and nine inches high, the depth to be measured by plunging to the bottom a small slip of soft wood on which the water mark can be distinctly observed, and measuring this by the scale before mentioned, the depth being recorded to the quarter of a tenth of an inch. Special instructions will be given that the rain be measured immediately after the fall or before any sensible evaporation has taken place. We have adopted the simple cylinder of uniform diameter as being less liable to errors of observation than any other form.

Although the separate observations are not read with the same minuteness as in the case of gauges in which the depth of rain is magnified by a receiver of less diameter than the orifice of the gauge, yet the average we find from experience in the case of a long series gives equally reliable results with those in which instruments of apparently greater precision are employed.

After the completion of the rain tables, our computers will commence the discussion of the temperature of the North American continent. Were our funds sufficient, we should be glad to include in the investigation all the observations made on this continent during the various expeditions to the arctic regions, undertaken by the British government, few of which have, as yet, received that thorough examination necessary to obtain from them the general truths which constitute real contributions to science.

We have mentioned in previous reports that the meteorological system of the U. S. army was about to be reorganized under the Surgeon General. This work has been carried on during the year, and a series of standard instruments has been constructed by James Green, of New York, under the direction of Dr. Craig, for distribution to the various posts. Fifty barometers and one hundred and fifty thermometers and rain gauges will be substituted for those now in use.

The number of Smithsonian observers during the year 1867 was 385, and this will probably be increased during the year 1868, so that a more rapid and accurate accumulation of data relative to the meteorology of this country will be obtained than at any time heretofore.

The Department of Agriculture has continued during the past year to publish the monthly bulletin of meteorological observations, which is still received with much interest by farmers, as well as by meteorological observers. The preparation of the meteorological notes for

the present, as for previous years, has been in charge of Mr. Wm. Q. Force.

The importance of meteorological observations in their connection with agriculture is becoming better appreciated by the public, and we think it probable that in due time our government will follow the example of foreign countries in maintaining a more perfect series of observations than has as yet been established. The average temperature of the year and of the different seasons, the amount and frequency of rain, the time of early and late frosts, the length of the "growing summers" and the recurrence of years of abnormal drought or of low temperature, are all elements of great value in comparing the relative capacity of different parts of the country for special productions.

We have repeatedly stated in previous reports that our eastern seaboard is far more favorably situated in regard to the prediction of the occurrence of storms than the western coast of Europe, since it has been conclusively shown that the principal disturbances of the atmosphere in the temperate zone move from west to east. During the past year the attempt has been made by the Institution to resume with the co-operation of the telegraph lines the system of telegraphic indications of the weather which was interrupted by the war. We have, however, been unsuccessful, and indeed it can scarcely be expected that without some remuneration to the companies, the use of the telegraphic wires and the time of the operators should be given for the purpose.

The discussion and reduction of long series of observations of the weather at particular places have been continued. The contributions of this kind completed during the past year are deductions from the meteorological observations made at Brunswick, Maine, and Marietta, Ohio. The discussions and reductions were made at the expense of the Institution by Mr. Charles A. Schott, on the same plan as that adopted in the discussion of the observations in the Arctic Regions by Kane, McClintock and Hayes.

Between the years 1807 and 1859 inclusive, meteorological records were made with great regularity by the late Professor Parker Cleaveland, of Bowdoin college, at Brunswick, Maine, and after his death were consigned to this Institution for reduction and publication. The observations, though not intended by their author to be of a strictly scientific character, were yet found sufficiently valuable to warrant the expenditure of considerable labor in preparing them for the press.

Brunswick is on the Androscoggin river, about 25 miles N. 40° E.

from Portland, Maine, in latitude 43° 54′ 5, longitude 69° 57′ 4, and 74 feet above high water. The observations were made at 7 a. m., 1 p. m. and 6 p. m., and relate to indications of the thermometer and barometer, direction of the wind, state of the weather, amount of rain and snow, character of clouds, occurrence of thunder-storms, fogs, frost and hail, earthquakes, auroras, etc.

From these observations the mean temperature of each day of each month is deduced and arranged in tables. The mean temperatures, however, require a small correction in order to reduce them to the mean temperature of the day which would be given from twenty-four or hourly observations instead of only three observations. In the discussion of the temperature the correction applied on account of the irregular hours was deduced from a series of observations taken at every hour of the twenty-four at Toronto and Montreal, which are found to have been subjected to the same fluctuation of temperature as Brunswick. To understand this, perhaps the following explanation is necessary: By adding all the temperatures observed at each hour of the day, for example all at 6 o'clock, into one sum, and dividing these by the whole number of observations at this hour, we obtain the average or mean temperature of that hour, and by repeating the process for every other hour we obtain a series for each hour of the twenty-four; also, by adding together all the average temperatures of each hour of the day and dividing by twenty-four, we obtain the mean temperature of the day. If the mean temperature of the day be compared with the mean temperature of each hour, some of the latter will be a little above and others a little below the former; and as these differences are found to be the same over a large extent of country, we may apply them to observations made at one, two, or three hours, so as to get the same result which would be obtained had the observations been made at every hour during the twenty-four. Thus it has been found, from several series of hourly observations in different parts of the United States, that those made at 7 a. m., 2 and 9 p. m., give a nearer approximation to the mean temperature of the day than those made at any other hours. We dwell somewhat on this point because the idea has been prevalent that the best times for determining the mean temperature are at sunrise, noon and sunset. But since sunrise and sunset are variable hours, it is obvious that corrections similar to those we have mentioned above cannot be readily applied to them.

The observations at Brunswick, having been duly corrected in the way we have mentioned, present, during a period of *fifty-two* years,

a mean temperature of 44° 4′ Fahrenheit, which reduced to the level of the sea becomes 44° 6′.

The lowest mean temperature for any year occurred in 1859, and was 40°.31, and the highest was in 1840, 51°.60, giving a range of 11°.29, which is considerably larger than at places farther south in the United States. A table is given of the fluctuations of the annual mean temperatures, which, with others of a similar character, is directly available for the study of the secular changes of the temperature; or, in other words, for ascertaining whether within the period of instrumental observations the annual temperature has undergone any sensible variation. No indications of this, however, have been found. On the contrary, it appears from the observations made between 1807 and 1832, inclusive, that the annual temperature was 44°.10, and between 1833 and 1859, inclusive, it was 44°.70, a difference readily accounted for from errors of observation and change of instruments, and too insignificant to substantiate a change in climate. It has been observed in other parts of the earth that the annual temperature undergoes a periodical change at certain seasons of the year, and in this country it has been supposed that a similar change occurs, viz., a cold period about the end of May, and a warm one in October. The discussion of the observations for 52 years does not indicate any such periodical fluctuation at these times.

According to the average of 52 years, the warmest day falls on the 22d of July, or 31 days after the summer solstice, and has a mean temperature of 67°.7.

The coldest day on an average is the 18th of January, or 28 days after the winter solstice, having a temperature of 19°.9 Fahrenheit. On an average, the 20th of April and the 24th October have the same temperature as the mean of the entire year. The lowest record for the whole time is 30° below zero, and the highest 102° above.

The northwest wind on an average reduces the temperature 4°.6. The north lowers it 3°.1, and the northeast 3°.8. The southwest wind, on the contrary, elevates the temperature above its normal value 2°.6. In summer the effect of rain and fog is to lower the temperature 6°.5. In winter, snow, sleet or rain increases the temperature 4°.3. From 54,097 observations, the following is the proportional number of winds in 1,000:

South.	North.	West.	East.	S.W.	N.E.	N.W.	S.E.
29	40	51	29	311	143	320	77

From this it results that the most frequent are the northwest and southwest, the former in winter and the latter in summer. The least number of days in which rain fell was in February, the greatest in May. The greatest number of days in which snow fell was in January. The earliest snow occurred on the 26th September, 1808, and the latest on the 8th of June, 1816. On an average, snow falls in Brunswick on some day in May once in five years, and in October once every other year. The average number of rainy days is 64. The average number of snowy days is 30. The average amount of rain and snow is 44.68 inches. The greatest amount of rain during any one day was 8¼ inches, November 4, 1845. The greatest fall of snow was on the 10th of March, 1819, and measured 30 inches. The greatest number of rainfalls occur while the wind is from the northeast, and the least number while it is from the west. The northeast wind in winter is almost constantly accompanied by rain or snow, while in summer the southeast surpasses it as a vehicle of rain, a result evidently due to the position of the place of observation with respect to the ocean. The number of storms of thunder and lightning recorded during 51 years is 472, or about 9 a year. The greatest number occurred in July and August, the least in January and February. The total number of fogs is 1,135, or 22 in a year, the most dense of which occur in ummer, the least dense in winter.

July is the only month in which no frost is recorded. The earliest frost observed was August 3d, and the latest June 19th. On an average, the spring frost ceases after the first week in June, and the autumn frost commences after the first week in September. There were 34 hail storms—the greatest number in January, the least in August. The records notice the occurrence of seven earthquakes and 86 auroras, the greatest number of the latter in September and October.

The aurora also exhibits a maximum and a minimum. The maximum occurred in 1808, 1818, 1830, 1838, 1848, 1857, giving differences of 10, 12, 8, 10, and 9 years. This indicates an average period of about 10 years. Unfortunately the temperature of the barometer is not given, and therefore a reduction on account of the expansion of the mercury is not possible, and consequently the only use which has been made of the record has been to exhibit the monthly extreme values, together with their annual variations.

The barometric maxima reach their greatest value in December and their least value in June. The minima occur in August. The monthly range is the greatest at the period of greatest cold, in January, and the least range at the period of greatest heat, in July.

The observations at Marietta, Ohio, extend from 1817 to 1823, by Mr. Joseph Wood, and from 1826 to 1859, inclusive, by Dr. S. P. Hildreth, the whole presenting an almost unbroken series of 40 years. Marietta, the oldest town in the State of Ohio, is situated at the junction of the Muskingum and Ohio rivers, in latitude 39° 25′, longitude 81° 29′ west, about 580 feet above tide-water.

The registers embrace records of temperature, wind, pressure of the atmosphere, face of the sky, cloudiness, and precipitation in snow and rain. The observations of Mr. Wood were made at sunrise, 2 p. m. and sunset, and by Dr. Hildreth generally at 6 a. m., 2 and 9 p. m., in summer, and 7 a. m., 2 and 9 p. m., in winter. Deviations in both series from these hours are noted and corrections applied in the reductions.

Unfortunately a small portion of the manuscripts was lost by the fire which destroyed a part of the Smithsonian building in January, 1865. This loss was partly supplied by the monthly means which had been published by Dr. Hildreth in Silliman's Journal.

During the 40 Marietta years a mean temperature is shown of 52°.46. The mean temperature of 1828, the warmest year during the whole period, was 55°.38, and that of the coldest, 1856, was 49°.71, showing a range or variation of temperature of 5°.67, which is about the usual range of annual temperature, as indicated by shorter periods in our latitude. The discussion indicates no change of annual temperature during the whole period of 40 years, the mean temperature of the first 20 years being the same as of the last 20 years. Neither do these observations indicate any change in the temperature of summer or winter by comparing the first 20 with the second 20 years. We think it probable, however, that a full discussion of all the records collected by the Institution would show some slight change in the average temperature of summer and winter due to the exposure of the surface by the clearing away of trees, although no indications of a similar kind may be given in the mean temperature of the year.

The greatest fluctuation of temperature is in February, and the least in July and August. The lowest temperature during the whole period was 23 degrees below zero, Fahrenheit, at 7 o'clock a. m., January 20, 1852; the extreme highest 102 degrees at 3 p. m., July 14, 1859. These observations give an extreme range of temperature of 125 degrees, which, when compared with that of Europe, may be considered excessive; but, compared with that of other parts of America and Asia, is not unusual. From all the observations it appears that, on an average, the warmest day of the year is the 23d of July, and the coldest the 15th of January, while the days which have the

same temperature as the mean of the whole year are the 14th of April and the 15th of October.

The average temperatures of the seasons are as follows:

Spring	52°.88
Summer	71.51
Autumn	52.78
Winter	33.01

There have been observed by the meteorologists of Europe variations in the ordinary march of the change of temperature. Of these there is one about the beginning of December, and another about the middle of May, which are most conspicuous. The cause of such abnormal change of temperature must be either local or general; if the latter, its influence must be felt, perhaps, with some modification in all parts of the globe. The observations were examined in regard to these abnormal changes; but though they indicate a normal temperature about the beginning of December, they show a remarkable depression of temperature between the 25th and 28th of November, which is preceded by an elevation on the 22d. A similar depression, however, is not observed in the series for Brunswick.

The direction of the wind is recorded for 27 years to eight points of the compass, and the result as to the relative frequency of each in proportion to 1,000 is shown in the following table:

S.	N.	W.	E.	S.W.	N.E.	N.W.	S.E.
173	217	135	52	213	39	87	84

From this it appears that the majority of the winds are from the north and southwest, while the northeast and east winds are the least frequent. The south wind is more frequent in summer, and the west and northwest in winter. This differs slightly from the winds in Brunswick, Maine, where the wind of the greatest frequency is that from the northwest, and next from the southwest. The difference is probably due principally to the configuration of the surface.

The result of another investigation indicates an apparent secular change in the direction of the wind, similar to the one noted at Brunswick; but as the epochs are different, the subject requires the discussion of more extended observations at different places.

The discussion of the connection of the direction of the wind with

the temperature, from observations of 2,340 days, exhibits the fact that the warmest winds are from the southeast, south and southwest, all others being cold; the extreme difference being 15 degrees in winter and $8\frac{1}{2}$ in summer. The comparison of the direction of the wind and rain shows that the southwest wind in summer and the southeast in winter are accompanied by the greatest amount of precipitation, and that fair weather generally attends northerly winds throughout the entire year. In summer the easterly and in winter the westerly winds are also attended with fair weather. The average annual quantity of rain and melted snow is $42\frac{1}{2}$ inches; the least amount observed in any one year is 32°.46, and the greatest 61°.84, varying much less than is recorded of Brunswick. The greatest amount of rain in any one month is in June, and the least in January. The average number of rainy days in a year is 86. The quantity of rain is more equally distributed throughout the year than at Brunswick. The greatest fall of rain recorded on any one day was 4.25 inches, on the 3d July, 1844. The largest fall of snow, 15 inches, was on the 4th of December, 1833.

The indications of the barometer show a regular progression in the weight of the atmosphere, which attains its greatest value in January and its least between July and August.

Ethnology.—The subject of ethnology has, during the past year, continued to occupy a considerable share of the attention of the Institution. Renewed efforts have been made, by means of circulars and correspondence, to increase the collection of specimens illustrative of the different races of men inhabiting or who have inhabited this continent.

The very extensive collections of ethnological articles from almost every part of the world, made by the United States exploring expedition under Captain (now Admiral) Wilkes, having been placed in charge of the Institution, not only afford a basis for a comparison of the different modes of life and stages of advancement among existing tribes, but an important means of determining the ethnological relations of the natives of the present day to those whose ancient remains lie thickly strewn over our whole continent. For example, implements of stone and of bone are almost everywhere found, the workmanship of races that have long since disappeared, and of which the use would be difficult of determination, were not similar implements as to form and material found in actual use at the present day among savages, particularly those inhabiting the various islands of the Pacific ocean. Our object is to collect well-characterized specimens,

illustrative of the remains of ancient industry; first, for the formation of a collection as perfect as possible to be preserved in the national museum; and second, for duplicates to present to other institutions, with which we maintain relations of reciprocity. It may be observed that, in making exchanges of specimens, the object is not alone to enrich our museum, but to furnish the means throughout the world of a more comprehensive comparison, and consequently to facilitate the study of the various stages of the development of human invention.

During the past year large and valuable collections have been received from the northwest coast and from within the Arctic Circle, illustrative of the Indians and Esquimaux of these regions. We have been particularly desirous to awaken an interest in the exploration of the shell-heaps which have been found at various points along our coast. These are now known to be of an artificial character, and are frequently rich in specimens of the industry of the earlier inhabitants of this country. As to the archæological value of these shell-mounds, considerable difference of opinion prevails. They are even regarded by some as the work of known tribes of Indians, concerning whom we possess other and better sources of information; but, even if this be so, they would serve to illustrate peculiarities of customs, and should, in all cases, be explored and the materials found in them carefully preserved. From the specimens derived from the shell-deposits on the coast of Norway, the Scandinavian archæologists were enabled to divide the stages of civilization into three principal periods, namely: the stone age, the bronze or transition age, and the iron age. These divisions have been generally admitted as characteristic of the principal stages of human development, though they are not regarded as successive periods in the general advancement of the world, since the inhabitants of one country may be in the condition of the stone age, while those of others are in the full enjoyment of all the advantages of the iron epoch.

This division furnishes a ready means of classifying the various archæological objects, so as to exhibit the comparative civilization in different places at the same or at different epochs, and, though it may be superseded by a more philosophic classification, it forms an important step in the gradual advancement of a new science. Indeed, it has lately been proposed to divide the stone age into two—the palæolithic, or first stone age, and the neolithic, or second stone age; and from the discoveries which have been made of late, and which have been so cumulative, we can scarcely

question the conclusions to which they all seem to point, namely: that though the remains of man are found in a very recent geological period, yet, in a historical point of view, the antiquity of these remains is much greater than was formerly supposed. Those which belong to the palæolithic age are usually found in beds of gravel and loam, extending along river valleys and reaching a height sometimes of 200 feet above the present water level. That these beds were not deposited by the sea is proved by the fact that the remains which occur in them are those of fresh water, and not of marine animals. These deposits contain fragments of such rocks only as occur in the area drained by the river itself, and consequently at the time the deposit was formed the topography of western Europe could not have been very different from what it is at present. That the climate, however, was much more severe than it is now is shown by the character of the animals of which the bones are found in abundance, namely: the musk-ox, the woolly-haired rhinoceros, the lemming, and the reindeer—all arctic animals. The great antiquity of the period is inferred from several indications. The extinction of the large animals must have been a work of time, and neither in the earlier writings, nor in popular traditions, do we find any indication of their presence. Again the beds of gravel and loam, which in most cases are deposited in regular strata, would require a long succession of seasons, since we see how little effect is produced at the present time in the course of a number of years.

In these deposits mingled with the regular strata are found stone implements indicating the presence of reasoning beings previous to the time at which the strata were deposited. According to Sir John Lubbock, about 3,000 flint implements have been found in what he denominates the palæolithic age, in northern France and southern England, but no traces of pottery, nor evidence of the use of metals, nor even of polished stone implements, have yet been met with.

The neolithic age commences with a knowledge of a higher degree of art, at a period when polished axes, chisels, gouges, and other implements of stone, as well as hand-made pottery, were extensively used in western Europe. The objects peculiar to this period do not occur in the river drift gravel as in the previous period, except some of the simpler ones. The implements are remarkably numerous in Denmark and Sweden, while the palæolithic types are absolutely unknown there. It has hence been inferred that these northern countries were not inhabited by man during the earlier periods. The Danish shell-mounds belong to this period, as well as those of our own

country, and hence it becomes an important object of inquiry to determine whether any real types of the palæolithic age exist in North America. The two stone ages, however, are characterized by the use of stone or bone, to the exclusion of metal.

It is evident, from the specimens which have been collected, that there was a period when bronze was extensively used for arms and implements. This is particularly manifest in the examination of tumuli, in which stone and bronze implements are found existing together. Some of the bronze axes, in many cases, appear to be mere copies of those of stone, as indeed is the iron axe used by the pioneers in clearing the American forest.

The bronze age is also distinguished from the stone age by the bones of animals which are found mingled with the implements. Those of wild beasts prevail in the former, while those of tame beasts are most numerous in the latter. No articles of bronze have been found in this country, though those of copper, showing a less advance in art, are frequently found in ancient mounds.

The iron age appeared when the metal was first used for weapons and cutting instruments, and gradually extends into the twilight of history. From all the remains which have been found, it is evident that neither bronze nor stone implements were used in northern Europe at the commencement of the Christian era, and that the inhabitants of these regions were not as low in the scale of civilization as the accounts of their conquerors would seem to place them.

Exchanges.—The system of international scientific and literary exchanges, to facilitate the correspondence between learned institutions and individuals of the Old and New World, has been fully maintained during the past year, 1,083 boxes and packages having been sent out, and 782 received since the date of the last report, most of them with a large number of sub-parcels enclosed.

These packages, as in former years, contain the publications of institutions, public documents, transactions of societies, scientific works presented by individuals, specimens of natural history, ethnology, &c. This part of the operations of the establishment has found much favor with the public. "We have nothing of the kind," says a recent English publication, "in this country, and the difficulty in exchanging books and specimens is much felt. The comparative cheapness of freight is more than made up by the complicated agencies and other extra charges, which can scarcely be avoided even by those initiated in the secrets of the business. The sending one

or two volumes or a small packet of specimens into Germany is often prevented by the difficulties and expense attending it."

At stated periods the following circular is distributed to institutions and individuals in America :

"The Smithsonian Institution is now making preparations to send copies of its publications to the different libraries and societies in Europe and other parts of the world with which it is in correspondence. As in previous years, it will undertake the transmission and safe delivery of the publications of other American institutions on the following conditions :

"1st. The volumes or publications to be put up in compact packages, enveloped separately for each particular address. They must not be sealed, although they can be pasted up or tied. Unsealed letters relating to the contents of the package may be placed inside or sent separately. *In no case will sealed letters or packages be forwarded by the Institution.*

"2d. The packages must be addressed legibly, in full, (if German, they must be in Roman character,) and the name of the donor must be indorsed on each.

"3d. *The parcels must be delivered in Washington free of expense to the Smithsonian Institution.*

"4th. A detailed and full invoice of all the addresses on the parcels must be sent separately, in advance, by mail.

"5th. The parcels should conform as nearly as possible in length and breadth to the corresponding dimensions of the Smithsonian Contributions to Knowledge, if in quarto, or to half this size, if octavo. Octavo pamphlets should not be folded. No single package should exceed six inches in thickness.

"6th. No charge will be made for the expenses of sending from Washington, if the parcels be of moderate bulk. In any case the proportion of actual expenses will only be called for.

"If desired, the Smithsonian Institution will make the selection of the most suitable recipients of any publications. In this case nothing but the name of the donor need be marked on the parcels.

"The next transmission of packages from the Smithsonian Institution will take place about the 1st June.

"Parcels should be in hand a month earlier, and the lists sent by mail at the earliest possible moment. These will be wanted considerably in advance of the parcels, in order to make out the complete invoices for each different address before commencing to pack the boxes.

"Unless the above conditions are severally and strictly observed the parcels cannot be forwarded.

The cost of this system would far exceed the means of the Institution, were it not for important aid received from various parties interested in facilitating international intercourse and the promotion of friendly relations between distant parts of the civilized world. The liberal aid extended by the steamship and other lines, mentioned in previous reports, in carrying the boxes of the Smithson exchanges free of charge, has been continued, and several other lines have been added to the number in the course of the year. The names of this class of patrons of the Institution are given in the following list:

Pacific Mail Steamship Company, North German Lloyd Steamship Company, Hamburg American Steamship Company, General Trans-Atlantic Steamship Company, Inman Steamship Company, Cunard Steamship Company, Pacific Steam Navigation Company, Panama railroad, California and Mexico Steamship Company.

Important favors have also been conferred during the year by the Adams, the Harnden, and the Wells & Fargo Express Companies; Mr. S. Hubbard, of San Francisco, and Mr. George Hillier, of the New York custom-house.

As in previous years, the agents of the Institution are: Dr. Felix Flugel, in Leipsic; Mr. Gustave Bossange, in Paris; Mr. Wm. Wesley, in London; Mr. Fred Müller, in Amsterdam.

In view of the delays incident to the transmission of packages to Italy, the Institution has embraced a proposal from the Royal Institute of Milan, conveyed through the friendly intervention of the American minister, Hon. G. P. Marsh, to take charge of the exchanges with that country, and a number of boxes have accordingly been shipped to Milan, via Genoa, during the year.

Besides these agents, our countryman, Mr. James Swaim, now residing in Paris, has kindly consented to act as a special agent in superintending the construction of such articles of philosophical apparatus as the Institution may require.

During the session of 1866–'67 an act was passed by Congress providing for the reservation of fifty complete sets of all the works published at the expense of the United States, to be placed provisionally in the hands of the Joint Library Committee of Congress, in order to be exchanged, through the Smithsonian agency, for corresponding publications of other nations. The object in this was to secure regularly and systematically, at the least possible expense, all reports and

other documents relative to the legislation, jurisprudence, statistics, internal economy, technology, &c., of all nations, so as to place the material at the command of the committees and members of Congress, heads of bureaus, &c. No appropriation was made for meeting the necessary expenses, which, of course, could not be borne by the Smithsonian fund, since all the returns were to belong to the Library of Congress; but as a year would necessarily elapse before any documents would be ready for distribution, it was thought proper to defer further action until the present season. In the mean time, however, a circular was issued by the Institution with the view of ascertaining what governments would enter into the proposed arrangement, and already replies have been received from a large number, all embracing the opportunity offered of procuring the national publications of the United States, and proffering complete series of their own in return. Some of these, indeed, have already sent large packages of their works without awaiting further action on the part of our government. Among them, one large box of books from the government of Victoria, Australia, has been received and the contents deposited in the Congressional Library.

In view of the great importance of securing the foreign works in question, we regret to learn that a difficulty has arisen in reference to the fifty sets referred to. The Public Printer does not consider himself authorized to furnish them without further legislation, since the distribution of the regular edition is already directed by law, and he cannot supply the fifty sets in question unless the regular edition be increased by that number. The attention of the Library Committee has been called to this subject, and it is probable that they will give it due consideration, as well as that of an appropriation to meet the necessary expenses.

The following is a list of governments which have responded favorably to the proposed international exchanges of documents, &c.:

France, Belgium, Great Britain and Ireland, Switzerland, Spain, Costa Rica, Netherlands, Chile, Denmark, Argentine Confederation, United States of Colombia, Wurtemburg, Finland, Hamburg, Baden, Sweden.

At the suggestion of Hon. John Bigelow, late American minister to France, a request was made by the Institution that some of the principal publishers of school-books in this country would furnish copies of their elementary text-books, in order that these might be presented to Professor E. Laboulaye, of the College of France, for examination, with a view to the application of some of their peculiar features to

the purposes of instruction in his own country. The character of this distinguished professor, and his known admiration of American institutions, secured for this request the prompt and liberal response of several publishers, a list of whom, with the number of works contributed, is as follows:

Harper & Brothers, New York	62 volumes.
A. S. Barnes & Co., "	26 volumes.
Oakley & Mason, "	10 volumes.
C. Scribner, "	3 volumes.
H. Cowperthwait & Co., Philadelphia	10 volumes.
U. Hunt & Son, "	12 volumes.
E. C. & J. Biddle, "	12 volumes.
A. S. Davis & Co., Boston	6 volumes.
Sargent, Wilson & Hinkle, Cincinnati	33 volumes.

Professor Laboulaye, in acknowledging the receipt of these 174 volumes, says: "These books form the admiration of all who take an interest in education, and I hope that France will profit by this example. We have excellent things at home by which you in turn might profit, but we have seen nothing comparable to your readers, your object-lessons, your graphics, and your geographical series."

Explorations and Collections.—The system of explorations mentioned in the preceding reports has been continued as in previous years, with the co-operation, in some cases, of other institutions and of persons interested in special branches of natural history. The objects of these explorations are to collect information and illustrations of the natural history, the ethnology, meteorology, and physical geography of the various parts of the continent of North America. The organization of these expeditions has been specially in charge of Professor Baird, who has devoted, with his wonted zeal, a large amount of labor to the preparation of outfits and to the care and arrangement of the specimens obtained. We shall give an account of these several explorations under the names of the districts within which they have been prosecuted.

British and Russian America.—In previous reports a statement has been given relative to the scientific department of the expedition organized by the Western Union Telegraph Company, for the purpose of effecting an electric communication between the United States and Europe, across Behring's Straits, and we have now to express our regret that the enterprise has been abandoned. We have, too, to deplore the sudden death of Mr. Kennicott, the director of the natu-

ral history department of the expedition, which took place in May, 1866, at Nulato, on the lower Yukon. In this dispensation of Providence, science has lost an ardent and successful votary, and the Institution one of its most valued collaborators. It is to him that we owe our introduction to the most important sources of information relative to the fur countries, and it is principally through his exertions that the museum of the city of Chicago, of which he was the director, received its endowment and organization.

After the death of Mr. Kennicott, Mr. W. H. Dall succeeded him as chief of the scientific corps, and has since been occupied in exploring the Yukon river from Fort Yukon to its mouth. He is still engaged in this work, but will probably return in the autumn of 1868.

To the co-operation of Col. Bulkley, the chief of the survey, and of Messrs. Scammon, Ketchum, Fisher, Smith, and others mentioned in the list of donors to the collections, much of the success of the operations relative to natural history is due. The collections themselves were made principally by Messrs. Kennicott, Dall, Bischoff, Bannister, and Elliott. Since the return of the surveying parties all the maps and reports relating to the geographical part of the work have been placed in possession of this Institution, with a view to their being elaborated in the form of a memoir for publication.

The explorations under the auspices of the telegraph company were made partly in Nicaragua during the transit of the scientific corps across the Isthmus, partly in the vicinity of San Francisco while the expedition was in process of being organized, partly in Kamtschatka and in British Columbia, but chiefly in the island of Sitka and on Norton Sound and the Yukon river.

The collections from the Yukon and Norton Sound region, as well as those from both sides of Behring's Straits, are very extensive and valuable. Among the results most interesting to the naturalist is the discovery at Norton Sound and at Nulato of three genera of birds* previously supposed peculiar to the Old World.

The collections of the telegraph expedition at Sitka were made by Mr. Ferdinand Bischoff, during a stay of about fourteen months, and are of great extent and value. Desirous of having a collection of specimens from Kamtschatka for comparison with those from the shores of Russian America, the Institution, conjointly with the Chicago Academy of Sciences, engaged the services of Mr. Bischoff for that purpose, and furnished him with a complete outfit, while the Pacific Mail Steamship Company, in its usual spirit of liberality as regards

* Species of Budytes, Phyllopneuste, and Pyrrhula.

the interests of science, gave him a free passage to San Francisco. Thence he sailed, still free of expense, in one of the vessels of the Russian Telegraph Company, but no stop being made at Kamtschatka, he was obliged to proceed to Plover Bay, the telegraphic depot on the Asiatic side of the straits, where he failed not to make some interesting collections. Returning with the vessel to San Francisco in October, he was directed to proceed to Mazatlan, and there, under the direction of the valued correspondent of the Institution, Colonel Grayson, he is now engaged in prosecuting his researches, but intends to return in the spring and proceed to Kodiak, where he will probably remain for a year, collecting specimens and exploring the country. It is proper to mention that he was also provided with a free passage to Mazatlan, through the kindness of Mr. Halliday, on the vessels of the Mexican, Oregon, and California line.

It was known that the Institution had for several years been diligently engaged in gathering specimens and collecting information to illustrate the character of the northwest portion of the American continent, and consequently, when the question of the acquisition of Alaska by the United States came under discussion, it was to the Institution that reference was chiefly made by the State Department and the Senate for information in regard to the country. Two of our collaborators, then on a visit to the Institution, Mr. Henry Bannister, who had spent a year in Norton Sound, and Mr. Bischoff, who had passed the same length of time at Sitka, were called upon to give evidence before the Committee on Foreign Relations, and were, in effect, the only persons examined who were acquainted with the region from personal observation. Professor Baird also gave valuable information as to the zoology of the country, from the materials which had previously been collected by the Institution.

For the purpose of obtaining additional information relative to the new Territory of Alaska, an expedition was organized by the Treasury Department, under the charge of Captain W. A. Howard of the revenue service, and, at the request of the Secretary of the Treasury, instructions for research into the physical and natural history of the country were furnished by the Smithsonian Institution. The expedition left San Francisco on the revenue steamer Lincoln, under command of Captain T. W. White, during the summer of 1867, and spent several months in its explorations. It was accompanied by a special party from the Coast Survey under charge of Mr. George B. Davidson, who has since communicated a valuable memoir on the country to the Superintendent of the Coast Survey, which has been printed by Congress. Important collections in natural history and ethnology have

been supplied to the Institution by Captains Howard and White, and Mr. Davidson.

The officers of the Hudson's Bay Company, especially at posts in the Mackenzie river district, have continued during the past year to make contributions in the way of information and specimens. Prominent among these may be mentioned, as in previous years, Mr. R. McFarlane of Fort Anderson, to whom we are indebted for an almost exhaustive collection of materials from the Arctic coast; Messrs. James Lockhart, Strachan Jones, C. P. Gaudet, W. Brass, J. and A. Flett, R. McDonald, J. McDougall, and James Sibbiston. To Mr. B. R. Ross the Institution owes a valuable contribution from Hudson's bay, embracing the first specimens of a large bird, the *bernicla leucopsis*, known to have been found in North America. It is intended to embody the result of the observations of our correspondents in Arctic America in a memoir, which will form an interesting addition to the ethnology, natural history and physical geography of the country.

It may be said to the honor of the officers of the Hudson's Bay and Northwest Companies, that though secluded for years from civilized society, they manifest in general no want of interest in subjects which pertain to a wide range of human culture; and it may be claimed on the other hand for the Smithsonian Institution, that it has been not slightly efficient in enlivening their isolated and monotonous life by the incitements and facilities it has afforded them for the study and observation of the phenomena and objects of nature.

Mr. Donald Gunn, our veteran correspondent in the Red River settlement, has made, at our request, an expedition to the lakes west of Lake Winnipeg, and obtained some rare and valuable specimens not previously in our collection. An account of his journey is given in the appendix to this report, and will, we doubt not, be read with interest, if only as the production of a man who has spent his life far removed from the centres of refined civilization.

Among the collections received through the telegraph expedition was a valuable series of specimens gathered on the northern end of Vancouver's island by Mr. A. W. Heisen, an American resident, these being the first ever received from that region.

Western America.—Mr. J. G. Swan, of Neaah Bay, Washington Territory, whom we have mentioned as favoring the Institution with an interesting memoir on the Makah Indians, has continued his valuable contribution of marine animals and ethnological specimens. Extensive series of marine invertebrates and eggs of birds have been received from Dr. P. A. Canfield, of Monterey, and Dr. Cooper has furnished some rare eggs and nests. The remainder of a large col-

lection made by Dr. Coues in the vicinity of Prescott, Arizona, has also come to hand. Reports forming valuable contributions to the general natural history of the Territory have been published by Dr. Coues in the proceedings of the Philadelphia Academy of Natural Sciences, and in the American Naturalist, based on the specimens in the Smithsonian collection. Dr. E. Palmer, formerly associated with Dr. Coues in collecting in the vicinity of Prescott, and devoting himself while there especially to the plants and insects, has since spent some time in southern Arizona at Camp Grant, and procured copious collections in all branches of natural history, as well as full series of objects made or used by the Apache Indians, which he has presented to the Institution.

Interior mountain regions.—Dr. C. Wernigk has made explorations in Colorado and Montana, and presented specimens to the Institution for determination and addition to the collections.

During the summer of 1867, Dr. F. V. Hayden was engaged in a geological survey of Nebraska, under the direction of the Commissioner of the Land Office, and made extensive collections of fossils and other specimens, which Mr. Meek, of the Institution, is now engaged in determining. Dr. Minor, of the Winnebago reserve, has supplied many specimens of ethnology and zoology. To Mr. Allan Mudge and Dr. Crocker, of Kansas, we are also indebted for important contributions from the last-named State. During the past year an exploration of the geology of the region along the 40th parallel of latitude, and eastward from California, was authorized by Congress at the request of the War Department, and the expedition was placed by the Secretary of War under the charge of Mr. Clarence King, who, for several years, had been the assistant of Professor Whitney in the geological survey of California. On application by Mr. King, the Institution took charge of the preparation of the natural history outfit of the expedition, made arrangements to receive all its collections, and to give such necessary facilities for working up the results as are usually afforded to the scientific parties of the government. Besides the regular assistants, Mr. King is accompanied by Mr. Robert Ridgway as zoologist, and Mr. Bailey as botanist. The collections already received are of much interest. The labors of the survey have so far been devoted to the examination of the celebrated Comstock lode of Nevada.

Eastern and Southern States.—Collections of more or less extent have been received from various contributors east of the Mississippi river, which will be found detailed in the list of donations. Dr. H. B. Butcher has completed his explorations in the vicinity of Laredo,

Texas, and has furnished a series of specimens, of which the collection of birds is especially valuable as throwing light on the distribution of species.

West Indies.—In connection with explorations in the West Indies, the Smithsonian Institution has to deplore the loss of Dr. Henry Bryant, of Boston, one of its most highly prized coadjutors in the work of American explorations. Not alone did he freely contribute of his abundant means, but he gave his personal services indefatigably to the extension of knowledge in the field of natural history. In both these respects the Institution had enjoyed his uniform co-operation as it shared the fruits of his successful labors. These labors had been principally conducted in Labrador, and on the Gulf of St. Lawrence, in Florida, in the Bahamas, in Cuba, and in Jamaica; and it was while pursuing his researches in Porto Rico that he met with an untimely death, occasioned probably by excessive exertion in an insalubrious climate. He died 2d January, 1867, at the little village of Arecibo, in the last-named island. Dr. Bryant contemplated a memoir on the birds of the West Indies, and was, at the time of his death, engaged in the prosecution of this object. His entire collection of the birds of the West Indies has been intrusted to Prof. Baird for determination, and after this has been effected it is the design of Mrs. Bryant to present a series of each species to the principal museums at home and abroad, in conformity with the intention of her lamented husband.

From Jamaica collections have been sent by Mr. W. T. March, in continuation of many previous contributions, and from Cuba by Mr. Bishop. Mr. A. E. Younglove spent several months in Hayti, and obtained a valuable series of birds and reptiles, embracing several new species. Mr. E. M. Allen, United States consul at Bermuda, has also given attention to the birds and marine animals of the islands, and has sent specimens.

Towards the close of the year an appropriation was made for a special exploration relative to the geology of the island of Petite Anse, in the Gulf of Mexico, near Vermillion bay, and the adjoining region, by Professor E. W. Hilgard, of the University of Mississippi. The immediate inducement for this exploration was the discovery of a stratum of rock salt on this island, together with the remains of extinct animals associated with specimens of human industry. The exploration was commenced too late in the season to be fully prosecuted. The weather, however, proved unusually favorable, the sugar-cane having bloomed on the Louisiana coast for the first time in 27 years. The exploration suggested many new questions, which can only be

answered by further investigation. The following is an abstract of the results already obtained:

"The Port Hudson deposit described by Carpenter, Lyell, and others, is the cypress swamp equivalent of the 'bluff formation,' just as the existing cypress swamps correspond to the Mississippi alluvium. The three islands, (out of the chain of five,) which were examined, consist of outliers of 'orange sand,' which has resisted denudation; on and around which, strata precisely similar to those of Port Hudson have subsequently been deposited. The rock-salt of Petite Anse island underlies the orange sand, and is, therefore, anterior to the drift, and it may probably be reached at points much higher above tide level than has been supposed, obviating the chief difficulty (that of drainage) heretofore experienced in working the deposit, the lowest part of which only has thus far been explored. While the precise position of the deposit, as regards the inferior formations, cannot now be determined, the results of the boring of the New Orleans artesian well render the conclusion almost unavoidable, in view of the absence of all signs of disturbance on the coast, that the salt deposit is of an age corresponding to that of the strata penetrated in this boring, which there is reason to believe are post-tertiary. Apart from all these comparatively ancient deposits, the entire delta is underlaid at or near tide levels by a cypress swamp deposit, as it would seem, of later date; and beneath these, as well as the more ancient deposits of a similar nature, there are beds of gravel of a composition similar to that of the main or Mississippi branch of the great stream of the orange sand epoch, which here appears to have divided into two branches, one reaching the gulf in the region of Vermillion bay, the other on or near the Sabine. Important information was obtained concerning the formations of northern Louisiana, which, while of course corresponding in general to those of Mississippi, differ so far as to promise a ready determination of the age of the grand gulf groups, which thus far remains in doubt, notwithstanding that those groups cover nearly half of the State of Mississippi, filling the space between the eocene and postpleiocene deposits. All that is known of it, is, that during its formation, palms flourished on the borders of an immense lake or everglade, which either bordered, or itself represented, the present gulf of Mexico. After what has been observed in Louisiana, there is less difficulty in accounting foı the total absence of animal fossils from this formation in Mississippi." But the problem to be solved regarding its age, extent, and relations to the eocene and quaternary shores of the gulf is one of so much interest that while in Louisiana Mr. Hilgard was

impressed with the importance of a more extended exploration than was at first contemplated, which, starting from the northern border of the marine eocene, above Vicksburg, should proceed diagonally across to the locality where petroleum has been found on the borders of Texas. So great was the interest manifested in regard to these matters wherever he went in Louisiana, that, were the affairs of the country at all settled, he has no doubt it would be easy to procure an appropriation or even subscription for the purpose.

Mexico.—The regular correspondents of the Institution in this country have continued their co-operation. Colonel Grayson, of Mazatlan, has furnished specimens from the vicinity of that city, and from other points in Western Mexico. At the joint expense of the Smithsonian Institution and the Boston Society of Natural History, he visited, last spring, the island of Socorro, one of the Revilligideo group, some hundreds of miles southwest of Cape San Lucas, and made an exploration of its natural history, obtaining several new species of birds. Returning via San Blas, he met with a severe loss in that city by the death of his son, the companion of his scientific labors, who was murdered by some unknown persons. The result of Colonel Grayson's investigations will shortly be published in the proceedings of the Boston Society of Natural History.

Professor Sumichrast and Mr. Botteri, of Orizaba, and Dr. Sartorious, of Mirador, have continued their valuable contributions, the latter gentleman in addition furnishing meteorological records.

Central America.—The collaborators in this part of the continent still continue active. From Guatemala Mr. Henry Hague has sent large collections of birds and mammals, and Dr. Van Patten, of vertebrata generally. From Costa Rica, the contributions of Dr. A. Von Frantzius, Mr. Endres, José Zeledon, and Mr. Juan Cooper embrace ample series in certain branches of zoology, while Mr. F. Lehmann has furnished an interesting collection of fossils and minerals.

The last of the collections made in Yucatan by Dr. Arthur Schott, during the exploration of that country instituted by Governor Salazar, have reached the Institution, and with the first portions received, furnish an excellent idea of the natural history of the northern part of the peninsula, the southern part of which will be illustrated by Dr. Berendt's researches.

As mentioned in a preceding report, Dr. H. Berendt, who has been many years one of our collaborators, undertook an exploration of the little-known interior of the Peninsula of Yucatan, under the auspices of the Institution, and at the expense partly of subscriptions by various societies and individuals. He first passed up the

Balize river, and thence to the region about Lake Peten, where he remained until the summer of 1867, making collections in natural history, and prosecuting researches in anthropology and geography. He visited the United States towards the end of the year, but will return shortly to Guatemala to complete his labors and to bring back his extensive collections.

An important collection of antiquities has been presented by the Hon. C. N. Riotte, late United States minister to Costa Rica. Mr. Geo. N. Lawrence, of New York, a collaborator of the Institution, is at present occupied in preparing a catalogue of the birds of Costa Rica, based chiefly upon the Smithson collection, which will probably include 500 species. To Dr. Von Frantzius the acknowledgments of the Institution are especially due for his valuable scientific correspondence and intelligent aid and supervision in conducting the explorations of the Institution in his adopted country.

Mr. Hardiman, of San Salvador, has contributed the first collection of birds received from that country. Mr. Osbert Salvin has presented a series of the birds of Veragua, collected by his correspondent, Mr. Arcé. Dr. Kluge, of Aspinwall, and Captain J. M. Dow, of Panama, have also continued their aid. The services of the latter in attending to the interests of the Smithsonian Institution on the Isthmus of Panama and the west coast of Central America, in issuing supplies, receiving and forwarding collections, &c., are of great value, and deserve the special acknowledgments of the Board of Regents.

South America.—The principal exploration in South America under the auspices of the Institution has been that of Prof. James Orton, of Rochester University, undertaken especially in the interest of the Lyceum of Natural History of Williams College, Massachusetts. The Institution lent the scientific instruments, supplied a considerable portion of the outfit, and took charge of the transportation and reception of the collections. Two parties were organized. The one under the immediate direction of Prof. Orton proceeded to Guayaquil via Panama, the other under Mr. W. B. Gilbert went to Venezuela. The party under Prof. Orton, after remaining some time at Guayaquil, where most of them were taken sick with yellow fever, finally arrived at Quito. Here they had the misfortune to lose one of their members, Colonel Phineas Stanton, a gentleman of many accomplishments, who volunteered to accompany the expedition as an amateur artist. After exploring in Pechincha and other localities on the plateau of Ecuador, they crossed to the head-waters of the Amazon, descending by Marañon to Para, and thence returned home. The

Venezuela division prosecuted their researches for a time in the district of Caraccas, and then returned via the Orinoco river. All the collections of both parties have been sent to the Institution for identification, and have been distributed for that purpose among the naturalists of the country.

A collection principally of birds and butterflies, made in the neighborhood of Bogota, was conveyed to the Institution through the attentive care of Hon. A. A. Burton, late United States minister. Many of the species are new as regards that locality. From Chile there has been received a collection, nearly complete, of birds prepared and determined by Prof. A. R. Phillippi, Director of the National Museum at Santiago. The series is of special value as containing types of many of the new species described by Prof. Phillippi and his associate, Dr. Landbeck.

An important Smithsonian exploration has been made during the last year in the Province of Buenos Ayres by Mr. W. H. Hudson, who has transmitted large collections of birds, which have been referred to Mr. P. L. Sclater and Mr. Osbert Salvin, of London, for examination, these gentlemen having been especially occupied in the study of South American birds. Mr. A. de Lacerda, of Bahia, has continued his valued contributions from that portion of Brazil.

With the exception of the Russian telegraph expedition at Plover bay, and on the Asiatic side of Behring's straits, the explorations we have enumerated have been confined to the American continent and its islands. This is in accordance with a settled policy of the Institution, to the effect that the natural and physical history of the Old World shall be relinquished to the explorers of Europe.

The following remarks by George Bentham, esq., president of the Linnean Society of London, present the scientific importance of explorations in this country in so clear a light that I may be excused for quoting them at length: "The peculiar condition of the North American continent requires imperatively that its physical and biological statistics should be accurately collected and authentically recorded, and that this should be speedily done. Vast tracts of land are still in what may be called almost a primitive state, unmodified by the effects of civilization, uninhabited, or tenanted only by the remnants of ancient tribes, whose unsettled life never exercised much influence over the natural productions of the country. But this state of things is rapidly passing away; the invasion and steady progress of a civilized population, while changing generally the face of nature, is obliterating many of the evidences of a former state of things. The larger races of wild

animals are dwindling down, like the aboriginal inhabitants, under the deadly influence of civilized man. Myriads of the lower orders of animal life, as well as of plants, disappear with the destruction of forests, the drainage of swamps, and the gradual spread of cultivation, and their places are occupied by foreign invaders. Other races, no doubt, without actually disappearing, undergo a gradual change under the new order of things, which, if perceptible only in the course of successive generations, require so much the more for future proof an accurate record of their state in the still unsettled condition of the country. In the Old World almost every attempt to compare the present state of vegetation or animal life with that which existed in uncivilized times is in a great measure frustrated by the absolute want of evidence as to that former state ; but in North America the change is going forward, as it were, close under the eye of the observer. This consideration may one day give great value to the reports of the naturalists sent by the government, as we have seen, at the instance of the Smithsonian Institution and other promoters of science, to accompany the surveys of new territories."

The total number of contributors to the collections of the Institution in 1867 was 163. The total number of primary boxes or packages received was 320. The general character of these additions will be learned from the table at the end of the report; they vary from single specimens to boxes filled with a variety of objects, the latter being far the most numerous. Among the most important may be mentioned the collections of the Russian telegraph expedition, those of Dr. Butcher, of Mr. Carmiol, of Colonel Grayson, of Professor Sumichrast, of Dr. Hayden, of Mr. Hudson, and of Dr. Palmer.

To the Zoological Garden of Hamburg, Dr. W. H. Sigel, director, the Institution is indebted for the present of a number of European house sparrows, which had been asked for with the view of naturalizing them in Washington and vicinity, in order to secure the aid of these nimble and voracious birds in ridding the fruit and shade trees of this region from noxious insects. Although 300 were embarked, only five reached the Institution (in August last) alive. These were immediately liberated and have remained in the proximity of the building during the winter. For further notice of these sparrows see general correspondence.

The Institution is indebted to Mr. T. A. Randall, of Warren, Pa., for a large number of living *menopoma alleghenensis* from the Allegheny river. Such of these as survived were sent to several of the Zoological Gardens of Europe, and others will probably be transmitted in the ensuing spring.

Investigations.—As in previous years, the natural history material collected by the Smithsonian Institution has been freely distributed to special investigators for examination and description, among whom are the following:

Thomas Bland, New York ; univalve shells from Mexico and Bogota. D. E. R. Beadle, Philadelphia ; shells of various portions of the globe. Dr. T. M. Brewer, Boston ; nests and eggs of North American birds, to be included in Part 2, North American Oology. Dr. P. P. Carpenter, Montreal ; mounted chitons and British shells, shells of Puget Sound, Santa Barbara, California, and Nicaragua. John Cassin, Philadelphia ; all the *Icteridæ*, *Rhamphastidæ*, and *Trogonidæ* of the Smithsonian collection, for monographing; birds collected in Ecuador, and on the Upper Amazon. Professor E. D. Cope, Philadelphia ; reptiles from Mexico, New Grenada, Navassa, Vancouver island, Sitka, &c.; entire Smithsonian collection of salamanders for a monograph ; recent and fossil bones of cetaceans and saurians. Dr. Elliot Coues, U. S. A., Columbia, S. C.; entire Smithsonian collection of *alcidæ* for a monograph. Thomas Davidson, London ; types of fossils for comparison. W. H. Edwards, Newburgh, N. Y.; lepidoptera of Mexico, Colombia, and western North America. D. G. Elliot, New York ; North American birds to be figured in his work on Birds of America. Professor T. Egleston, New York ; specimens of minerals from various parts of the world. John Gould, London ; types of new and rare species of humming birds, described by Mr. Lawrence, from the collection of the Smithsonian Institution. George N. Lawrence, New York ; various collections of humming birds, and general collections of birds of Costa Rica, Bogota, and western Mexico. Isaac Lea, Philadelphia; unionidæ from various portions of North America. Dr. Joseph Leidy, Philadelphia ; fossil remains of vertebrata from Colorado, &c. F. B. Meek, Washington ; invertebrate fossils, from Nebraska, &c. Lewis H. Morgan, New York ; skulls of American and European beaver. Baron R. Ostensacken ; diptera of Mexico, &c., insect galls from Plover bay, Northeast Siberia. Tryon Reakirt, Philadelphia ; lepidoptera of Colombia. Dr. I. T. Rothrock; plants collected in Russian America. S. H. Scudder, Boston ; orthoptera of Mexico and other parts of North America. Dr. W. Stimpson, Chicago ; marine invertebrata collected by Ferd. Bischoff, W. H. Dall and others, on the northwest coast of North America. Dr. P. L. Sclater, London ; collection of birds made about Conelutas, Buenos Ayres, by W. H. Hudson. Dr. John Torrey, New York ; collections of plants of various parts of the world. P. R. Uhler, Baltimore ; hemiptera of Mexico and America generally. Dr. H. C. Wood, jr.,

Philadelphia; general collections of myriapoda. Professor Jeffries Wyman, Cambridge; skulls of Pacific coast Indians. The *insects* have been sent to the Entomological Society of Philadelphia to be identified and preserved.

Professor Baird has continued, as other duties would permit, his investigations in regard to the birds of America, of which 450 pages have already been printed, under the title of "Review of American Birds in the Museum of the Smithsonian Institution." The object of this work is to define the absolute and comparative characters of the birds of America, and especially to trace with minute detail their distribution during the breeding season, and the extent and character of their migrations. He has also been engaged in digesting and collating for publication by the Institution the mass of original notes contributed by Mr. Kennicott, Mr. MacFarlane, Mr. Ross, and others, relative to the natural history of the regions north of the United States, which are believed to embody much original information.

The records of the Institution have also been largely drawn upon for materials required by part 2 of the North American Oology of Dr. Brewer. As explained in previous reports, the object of this work also is to present, in addition to the description of the nests and eggs of the species, a complete account of their habits and geographical distribution during the breeding season.

For the promotion of these objects, circulars and pamphlets containing the necessary instruction to collectors have been issued for several years past, and large returns obtained, which will greatly extend our present knowledge. The notes containing information attached to the specimens received by the Institution have been carefully transcribed, and systematically arranged, so as to supply conveniently any information required on the subjects referred to.

In all cases in which specimens have been presented or lent to investigators for facilitating their researches, or enabling them to pursue certain lines of investigation, it is required that full credit for the favor conferred, as far as the facts may justify it, shall be given to the Institution by the authors in their resulting publications. In most cases this recognition has been fully complied with, but in a few we are sorry to say the acknowledgments have not been of the character or extent to which the Institution was entitled.

The distribution of the duplicate specimens of the collections has been carried on as rapidly as practicable during the year. The most important series sent off have consisted of skins and eggs of arctic birds, skins of mammals, shells, minerals, and ethnological specimens. The

minerals were arranged and labelled for the purpose by Professor Egleston, the shells by Dr. P. P. Carpenter, the ethnological objects by Dr. E. Foreman. As the collections generally become reduced to order, identified, and duplicates eliminated, further distributions will will take place. According to the account of Professor Baird, nearly a quarter of a million of different specimens have thus been sent away to places where they are likely to be of use. It should be borne in mind that in nearly every instance these specimens had previously been identified and labelled by the highest authorities, and in fact served as types or standards of special reference.

The foregoing account of the disposition of the specimens collected by the Institution will serve to illustrate the spirit and policy of the establishment, as well as the working of the system of active operations in its relation to the advancement of natural history. The same policy, but with more efficiency, would be continued, were Congress to take charge of the museum, or make separate provision for its maintenance.

Besides the investigations in the line of natural history, several others have been commenced, at the charge and under the direction of the Institution and are still in progress. George Gibbs, esq., has been engaged in collating and arranging for publication all the Indian vocabularies which have been collected by the Institution. An appropriation has been made for a systematic exploration of mounds and ancient remains in certain localities, of which an account will be given in the next report. As is seen under the head of meteorology, the labors of Mr. Schott have been continued in the reduction and discussion of observations. An appropriation has been made to assist Prof. Wm. Ferrel in a series of investigations relative to the tides; and another to Prof. Newcomb, of the National Observatory, to defray the expense of numerical calculations for his discussion of the observations of the planet Neptune. The Secretary, in connection with General Poe, of the Light-house Board, devoted a part of his summer vacation to investigations in regard to the penetration of sound, in its relation to fog-signals. The remainder of the same vacation, as well as a considerable amount of other time, was devoted to the examination of subjects referred to him by the government, as presiding officer of the National Academy of Sciences.

In addition to the collaborators in natural history already mentioned, the Institution during the past year has been favored with the gratuitous services of a number of other gentlemen in reporting upon questions proposed for solution, in examining memoirs, and in the preparation of articles for the report. Among these may be mentioned Prof.

G. J. Brush, of Yale College; Dr. Gray, of Harvard; Profs. Newcomb and Harkness, of the Naval Observatory; Drs. Woodward and Craig, of the Surgeon General's Office; Prof. Schaeffer and Mr. Taylor, of the Patent Office; Mr. Gibbs, of Washington; Mr. C. Rau, of New York; Prof. Chace, of Brown University.

National Museum.—Much time has necessarily been consumed during the past year in repairing the damage sustained by the specimens and the gallery of exhibition in consequence of the conflagration of the upper part of the building in 1865. The defective state of the temporary roof permitted a large amount of moisture to enter the walls, which kept the hall in a constant state of dampness, covering the specimens with mould. The entire collection has, however, been examined, dried, and cleaned; the shelves and the interior of the cases, with the stands of the specimens, whitened; the ceilings and walls frescoed, and new paint applied to most of the woodwork.

The most important work connected with the museum has been the labelling and preliminary arrangement of the extensive collection of ethnological objects, and the separation of the duplicates. All the collections of vertebrata as received have been catalogued and put in place; many osteological specimens cleaned; bottles of alcoholic specimens washed, &c. The labelling and registering of the collection has been continued as rapidly as possible, 13,221 entries having been made during the year.

This museum is principally made up of the type specimens of the collections made by the various expeditions organized by the government, as well as those projected and supported by the Smithsonian Institution itself, and owes but little to donations, and still less to purchases. There is, however, a large debt due the Institution from foreign museums, in the way of exchange, which we have no doubt will be cheerfully discharged as soon as they are informed that Congress has made provision for the support of a museum on a more extended scale than that which the Smithsonian is able to maintain. Besides the increase of the museum from the addition of type specimens derived from the various collections examined and described during the year, a number of foreign donations have been received, among which are specimens of the products of the iron mines and manufactures of Sweden, presented by Hon. G. V. Fox, late Assistant Secretary of the Navy, and from the same donor large and beautiful specimens of graphite from eastern Siberia, both rough and wrought, as well as exemplifications of the rocks associated with it.

It may be recollected that when the government museum was transferred to the Institution, it was stipulated that an appropriation

should be annually made for it in this new depository, equivalent to the cost of its support while in the Patent Office; and the appropriation for this purpose had been limited until the last session of Congress to the sum of $4,000. But this sum, on account of the rapid increase of the collections and the great advance in prices, is not now nearly sufficient even for the preservation of the specimens, to say nothing of the equitable claim which the Institution might rightfully advance for interest on the money which it has expended in providing the accommodations for this museum. It is but just to say that, in view of the peculiar condition of our affairs, the appropriation was, last year, temporarily increased to $10,000; but even were this continued, it would be still quite inadequate to the suitable maintenance of a national museum.

National Library.—The transfer of the library of the Institution to the care of Congress, authorized in 1866, was completed during the last year. The reasons for making this transfer were given in full in the last report, but it may be proper briefly to recapitulate some of the leading points.

First. The collection and support of a large library is not in strict conformity with the will of Smithson, as now generally interpreted.

Second. The whole of the income would in time not be more than sufficient to meet the wants of a rapidly growing library, the tendency being to absorb more and more of the funds with the increase of the number of the books, and hence even a library adequate to the wants of the various departments of government can only be properly supported by the appropriations of Congress. The government has already commenced such a library, and even if there were no objections to expending the income of the bequest of Smithson in the purchase of books and the maintenance of a library, it would be unnecessary to establish two libraries in such close proximity.

Third. By combining the two libraries in one, the expense of accommodation, of care and of management will be much diminished, and a greater facility as to consulting the works afforded.

Fourth. The portion of the Smithsonian building in which the library was deposited is not fire-proof, and was filled to overflowing, while further accommodations and protection could not be afforded without encroachment on the funds which had been set apart as the permanent capital.

Fifth. By the terms of the transfer, the cataloguing, binding, and entire care and management of the books are at the expense of the

government, and consequently an important portion of the income is made available for active operations.

Sixth. The transfer has furthermore tended to awaken an interest in the library of Congress, which cannot fail to render it, under the energetic superintendence of the librarian, Mr. Spofford, worthy of the nation. At the last session of Congress an appropriation of $100,000 was made for the purchase of the library of Mr. Peter Force, consisting of books relating to America, and with these additions the library of Congress is the largest in the United States,* and may even now with propriety be denominated, as we have ventured to call it, the National Library.

By the law authorizing the transfer, the Institution is at liberty to draw any books it may require for its use either from its own collection or from those of Congress. It is proposed, as soon as the regents' room is properly provided with cases, to keep in the Institution such books as are most frequently required for consultation in its operations, and fortunately a considerable number of these are duplicates in the two libraries.

Seventh. The books transferred to the National Library are in many cases such as could not be obtained by purchase, and are presents to the Institution from the old libraries of Europe, consisting of transactions and other publications of learned societies, forming a special collection not only ranking first in this country, but one of the best in the world.

Neither is it the value of the books already transferred which is to be considered, but also the perpetual increase of the several series of scientific transactions in their continuations from year to year which are regularly supplied in exchange for the publications of the Institution.

The collections of transactions of societies contain the record of the actual progress of the world in all that essentially pertains to the mental and physical development of the human family, and as it has been the aim of the Smithsonian Institution from the first to establish exchanges with all societies of this character, the list of those now in the national library includes, with scarcely any important exception, the whole series of the world, and affords the means therefore of tracing the history of at least every branch of positive science since the days of the revival of letters until the present time.

The use of this library for the purpose of research will soon be much facilitated and its treasures brought more generally into requi-

* In January, 1868, it contained 165,467 volumes.

sition by the publication of the classified index of all the physical papers in the transactions of learned societies and in scientific periodicals which has been in course of preparation for the last ten years by the Royal Society of London, and of which the printing of the first volume has just been completed. It may be recollected that the preparation of this index resulted from a letter addressed to the British Association in 1855, by the Secretary of this Institution, setting forth the advantages to science of such a work, that the matter was referred to a committee of the Association, reported favorably upon, and recommended for execution to the Royal Society. As soon as this work is published copies will be procured by the principal libraries and institutions in this country. Any person, then, desiring to investigate a special point in any branch of science, will be able to find a reference to the transactions, journals or proceedings in which it is contained; and as the most perfect set of these is to be found in the National Library, it will become a centre of information on scientific subjects. It may also be remarked that the National Library is now accessible to all persons during every week-day in the year, with the exception of one month devoted to cleaning and arranging.

In the arrangement of the compound library the principal part of the Smithson collection, that is, the scientific transactions, will form a department by itself in which works of a similar character previously belonging to the library of Congress will be incorporated, while the miscellaneous books of the Institution will be arranged with the works of a similar class already in that library. A complete catalogue of all the transactions belonging to the Smithson library up to 1866 was prepared and published by the Institution, and a general catalogue of the whole National Library is now in the press, in which the books of the Institution are designated by the letter—S.

Some idea may be formed of the value of the annual contributions from the exchanges of the Institution, when it is mentioned that it includes the publications of 1,081 societies, besides large donations from governments, libraries, and individuals, and that these publications are principally of a very expensive character, illustrated by costly engravings and in many cases by colored plates. The following is a statement of the number of establishments in different parts of the world which have contributed to the Smithson library, and which it is expected will continue their contributions from year to year for an indefinite period.

Number of societies sending their publications in exchange to the Smithsonian Institution.

Germany	334	East Indies	4
Great Britain and Ireland	194	Chile	4
France	113	Portugal	3
United States	100	Turkey	3
Italy	70	Mauritius	2
Holland	48	Africa	2
Russia	46	China	2
Switzerland	35	Brazil	2
Canada	20	Greece	1
Belgium	19	Egypt	1
Australia	15	Bogota	1
Denmark	13	Buenos Ayres	1
Sweden	12	Jamaica	1
Hindostan	11	Mexico	1
Norway	9	Trinidad	1
Spain	7		
Cuba	6	Making in all	1,081

To the list of correspondents during the past year we may add the Institute of Egypt, founded at Alexandria, in 1859, from which we have received the first volume of its transactions and several numbers of its proceedings. These works form, as it were, an epoch in the history of modern civilization, which, originally cradled in the valley of the Nile, now returns, after having changed the condition of western Europe, to the place of its birth, destined, we trust, to rouse from its long apathy "the country in which Pythagoras courted wisdom and Herodotus unveiled the sources of history." A library and collections have been formed, which are rapidly increasing, and which even now it is stated are capable of rendering essential service to the explorers of the valley of the Nile. Although the French language has been adopted for the reports and also for correspondence between the members of the society and the learned institutions of the west and east, yet the contributions of authors are presented in their original form and style, and hence the present volume includes memoirs in French, Italian, Greek, and Arabic, with illustrations in the hieroglyphic, Coptic, and Hebrew. To some of these memoirs, explanations, rather than strict translations, are appended.

The following is a statement of the books, maps and charts received by exchange, in 1867, and deposited in the National Library:

Volumes:		
Octavo	1,088	
Quarto	383	
Folio	86	
		1,557
Parts of volumes and pamphlets:		
Octavo	2,689	
Quarto	1,057	
Folio	200	
		3,946
Maps and charts		328
Total receipts		5,831

Among the more interesting additions to the library during the year is the work of Dr. Hochstetter, on New Zealand. This gentleman was one of the scientific corps of the celebrated Austrian exploring expedition on board the Novara, and when the vessel arrived in New Zealand, he was left, at the request of the governor of the colony, to make a geological exploration of the islands. The results of his labors are embodied in a special work, which conveys a great amount of information relative to the geography and natural history of the country. Originally published in the German language, an English translation has appeared in Stuttgardt, made by Mr. Edward Sauter, of Little Rock, Arkansas, to whom we are indebted for a copy of the work.

But perhaps the most valuable donation received during the past year is that from Hon. G. V. Fox, late Assistant Secretary of the Navy, through the Department of State. It consists of articles presented to him on the occasion of his recent visit to Russia as the bearer to the Emperor of a resolution of Congress congratulating his Majesty on his escape from assassination. They embrace 179 volumes, finely bound, many in quarto and large octavo ; 15 atlases and albums, some "eagle," others "elephant" folio size, all bound in cloth or morocco ; 72 maps, some in covers and cases ; 4 city plans, in cases, and 12 pamphlets—making in all 283 pieces, illustrating the physical geography, ethnology, and resources of the Russian empire. The character of this gift will be properly appreciated when it is stated that, by a joint resolution of Congress, Mr. Fox was author-

ized to accept these books as additions to his own library, but, with commendable liberality, he has presented them to the Smithsonian Institution, to form part of the collections deposited in the National Library. They are principally in the French and Russian languages, and we have availed ourselves of the services of Mr. H. H. Kalusowski, of the Treasury Department, for the means of access to a knowledge of their rich contents.

The following are also some of the larger donations received in 1867:

Riksbiblioteket, Stockholm, 44 volumes.

Bergeurk Museum, Bergen, Norway, 8 volumes and 7 pamphlets.

Imperial Academy of Sciences, St. Petersburg, 11 volumes and 16 pamphlets, completing some of the early series of their publications.

Hydrographical Department of the Ministry of Marine, St. Petersburg, 38 volumes, 7 pamphlets, and 174 charts.

Imperial Free Economical Society, St. Petersburg, 12 volumes "Transactions."

Finland Society of Sciences, Helsingfors, 13 volumes.

Imperial Geographical Society, St. Petersburg, 16 volumes and 33 pamphlets.

Verein zur Beförderung des Gewerbfleisses in Preussen, Berlin, 40 volumes and 2 pamphlets, nearly completing the "Verhandlungen."

Kais. Akademie der Wissenschaften, Vienna, 13 volumes and 33 pamphlets.

K. Statistisch-Central-Commission, Vienna, 37 volumes and 60 pamphlets.

R. Istituto Lombardo di Scienze, Lettere ed Arti, Milan, 15 volumes and 27 pamphlets.

Ministero di Agricoltura, Industria e Commercio, Florence, 10 volumes and 2 pamphlets.

R. Istituto d' Incorragiamento alle Scienze Naturale, Economiche e Technologiche, Naples, 17 volumes and 23 pamphlets.

British Archæological Association, 16 volumes and 9 pamphlets, nearly completing the "Journal."

British Museum, 9 volumes.

Museum of Practical Geology and Geological Survey, London, 10 volumes and 19 pamphlets.

Institut Egyptien, Alexandria, the first volume of transactions and 9 numbers of bulletin.

Mining Department, Melbourne, 12 volumes and 17 pamphlets.

Real Sociedad Economico de Amijos del Pais, Habana, 256 volumes, chiefly theological.

American Board of Commissioners for Foreign Affairs, Boston, 36 volumes and 53 pamphlets.

Massachusetts State Board of Agriculture, 13 volumes and 7 pamphlets.

J. G. Cotta, Augsburg, 15 volumes.

Dr. Karl Koch, Berlin, 205 pamphlets.

Justus Perthes, Gotha, 12 volumes and 16 pamphlets.

F. A. Brockhaus, Leipzig, 13 volumes and 6 pamphlets.

Before concluding the history of the Institution for 1867, it becomes my duty to recall a painful event, which was announced to the Board at its meeting in February last. I allude to the death of Alexander Dallas Bache, the head of the United States Coast Survey, and one of the original members of the Board of Regents. On the occasion of the announcement of this bereavement, which was received with emotions of profound sorrow, the following resolutions, presented by Hon. J. W. Patterson, of New Hampshire, were unanimously adopted:

"*Resolved*, That the highest honor is due to the memory of our respected and beloved associate, Professor ALEXANDER DALLAS BACHE, who, through so many years of active life, has devoted, unselfishly and with untiring energy, great talents, profound acquirements and undeviating integrity to the advance of art, science, education and philanthropy.

"*Resolved*, That in the death of our lamented associate this Institution, of which he was a regent, and one of the executive committee from its first organization to the time of his death, has lost an efficient collaborator, a sagacious counsellor and zealous supporter.

"*Resolved*, That the members of the Board, in common with the Secretary, lament in his departure the loss of a warm and tried personal friend, and that they will always cherish the memory of his genial and sympathetic disposition, his gentle and prepossessing manners, his refined taste, high moral perceptions and unswerving advocacy of the right.

"*Resolved*, That a copy of these resolutions be transmitted to the widow of the deceased, and that the Secretary prepare a suitable eulogy for insertion in the next annual report."

In compliance with the resolution of the board, I have collected materials for a memoir of my lamented friend, Dr. Bache, and prepared as full an account of his life and labors as my time and ability would permit. The duty thus devolved upon me would have been accepted with alacrity as a means of gratifying my feelings of regard

and veneration had it not been associated in my mind, from the first, with a sense of its difficulty and responsibility. I was aware that it was not enough to narrate the events of his life, and to give a recital of his numerous and diversified labors; but that it would also be necessary to analyze his mental and moral constitution, as well as to trace the influence which his career has had, and will continue to have, on the advancement of science and education in this country. To fulfil this satisfactorily, though a duty not to be declined, is a labor requiring much care, and involving much solicitude. The sketch which I have prepared has been sent to Gen. Sabine for insertion in the proceedings of the Royal Society of London, and in view of my other pressing duties, it will be difficult for me to present the complete eulogy to the board at its present session. I therefore crave the indulgence of being allowed to defer the publication until the appearance of the report for 1868.

Respectfully submitted:

JOSEPH HENRY,
Secretary Smithsonian Institution.

WASHINGTON, *January*, 1868.

APPENDIX TO THE REPORT OF THE SECRETARY.

FROM THE REPORT OF PROF. S. F. BAIRD.

A.—*Table showing the statistics of the Smithsonian exchanges in* 1867.

Agent and country.	Number of addresses.	Number of packages.	Number of boxes.	Bulk of boxes in cubic feet.	Weight of boxes in lbs.
Dr. FELIX FLÜGEL, *Leipsic*—					
Russia	49	70	....	....	....
Germany	336	395	....	....	....
Switzerland	35	42	....	....	....
Total	420	507	46	443	10,835
FREDERICK MÜLLER, *Amsterdam*—					
Sweden	13	22	....	....	....
Norway	6	8	....	....	....
Denmark	14	20	....	....	....
Iceland	1	1	....	....	....
Holland	51	68	....	....	....
Belgium	19	21	....	....	....
Total	104	140	15	146	2,780
G. BOSSANGE, *Paris*—					
France	113	122	....	....	....
Spain	7	7	....	....	....
Portugal	3	4	....	....	....
Total	123	133	8	90	2,188
I. R. ISTITUTO, *Milan*—					
Italy	70	79	5	35	1,020
W. WESLEY, *London*—					
Great Britain and Ireland	197	230	24	186	4,200
Rest of world	87	101	15	75	1,500
Total	1,001	1,190	113	975	22,523

B.—*Packages received by the Smithsonian Institution from parties in America for foreign distribution in* 1867.

	No. of pkgs.
Albany, N. Y.—	
Albany Institute	16
Dudley Observatory	7
New York State Agricultural Society	55
New York State Homœopathic Society	6
Secretary of state	12

	No. of pkgs.
Boston, Mass.—	
American Academy of Arts and Sciences	124
Board of State Charities	34
Boston Society of Natural History	496
Municipality of Boston	1
Dr. Brewer	1
S. H. Scudder	2
Charles Sumner	100
Drs. Warren and Storer	50
Brooklyn, N. Y.—	
Long Island Historical Society	12
Cambridge, Mass.—	
American Association for Advancement of Science	55
Cambridge Observatory	200
Harvard College	24
Museum of Comparative Zoology	525
Prof. Asa Gray	19
Columbus, Ohio—	
Ohio State Board of Agriculture	102
Easton, Pa.—	
Rev. Lyman Coleman	10
Hartford, Conn.—	
American Asylum for Deaf and Dumb	16
Janesville, Wis.—	
Institution for the Blind	12
Little Rock, Ark.—	
State of Arkansas	20
Martindale, N. Y.—	
Rev. W. I. Loomis	20
Montreal, Can.—	
Prof. J. W. Dawson	33
New Bedford, Mass.—	
J. H. Thomson	1
New Haven, Conn.—	
Connecticut Academy of Sciences	50
Prof. G. J. Brush	1
Prof. J. D. Dana	31
Prof. O. C. Marsh	50
Prof. A. E. Verrill	11
New York, N. Y.—	
American Institute	54
New York Lyceum of Natural History	116
American Christian Commission	170
United States Sanitary Commission	99
Mrs. Samuel Colt	16
A. M. Edwards	1
Dr. J. S. Newberry	9

	No. of pkgs.
Northampton, Mass.—	
State Lunatic Asylum	36
Philadelphia, Pa.—	
Academy of Natural Sciences	184
American Pharmaceutical Association	7
American Philosophical Society	460
Conchological Section, Academy Natural Sciences	72
Historical Society of Pennsylvania	25
Numismatic and Antiquarian Society	21
Pennsylvania House of Refuge	100
Pennsylvania Institution for Deaf and Dumb	100
Prison Discipline Society	100
Public Schools	96
James Barclay	3
Rev. E. R. Beadle	9
Henry C. Lea	4
Princeton, N. J.—	
A. D. Brown	4
Providence, R. I.—	
Dr. E. M. Snow	65
Edwin M. Stone	15
Quebec, Can.—	
Literary and Historical Society	34
Salem, Mass.	
Essex Institute	116
Dr. A. S. Packard	6
San Francisco, Cal.—	
California Academy of Natural Sciences	54
St. Louis, Mo.—	
Academy of Sciences	7
St. Paul, Min.—	
Minnesota Historical Society	18
South Bethlehem, Pa.—	
Dr. C. M. Wetherill	26
Toronto, Can.—	
Canadian Institute	5
Washington, D. C.—	
Columbia Institute for Deaf and Dumb	50
Hydrographic Office, Navy Department	61
Medical Department United States Army	51
Public Schools	200
Secretary of War	500
United States Coast Survey	141
United States Engineer Department	2
United States Hospital for Insane	28
United States Naval Observatory	188
United States Patent Office	216

Washington, D. C.—Continued.	No. of pkgs.
Cleveland Abbe	1
Archibald Campbell	9
J. Disturnell	1
Admiral Davis	60
Dr. Elliot Coues	50
Th. Poesche	3
J. H. C. Coffin	6
A. R. Rossler	1
Peter Force	300
Dr. King	20
	6,016

C.—*Packages received by the Smithsonian Institution from Europe in* 1867, *for distribution in America.*

	No. of packages.		No. of packages.
ALBANY, NEW YORK.		BOSTON, MASSACHUSETTS.	
Albany Institute	6	American Academy of Arts and Sciences	107
Bureau of Military Statistics	4	American Statistical Association	10
Dudley Observatory	21	American Unitarian Association	3
Homœopathic Medical Society	1	Boston Christian Register	3
New York State Agricultural Society	18	Boston Journal of Medicine	1
New York State Library	26	Boston Society of Natural History	209
New York State Medical Society	3	Bowditch Library	3
New York State University	6	Christian Examiner	3
State Cabinet of Natural History	2	Massachusetts Historical Society	2
AMHERST, MASSACHUSETTS.		Mercantile Library Association	1
		North American Review	3
Amherst College	1	Perkins Institution for the Blind	2
		Prison Discipline Society	1
ANN ARBOR, MICHIGAN.		Public Library	10
		State Library	7
Observatory	6		
		BUFFALO, NEW YORK.	
AUGUSTA, MAINE.			
		Historical Society	1
Maine Insane Hospital	1		
		BRATTLEBORO', VERMONT.	
AUSTIN, TEXAS.			
		Vermont Asylum for Insane	1
Texas State Lunatic Hospital	1		
		BROOKLYN, NEW YORK.	
BALTIMORE, MARYLAND.			
		Long Island Historical Society	1
Maryland Academy	1		
Maryland Historical Society	5	BRUNSWICK, MAINE.	
Medical Hospital for Insane	1		
Peabody Institute	1	Bowdoin College	1
BLACKWELL'S ISLAND, NEW YORK.		BURLINGTON, VERMONT.	
New York City Lunatic Asylum	1	University of Vermont	1

Packages received by Smithsonian Institution, &c.—Continued.

	No. of packages.
CHARLOTTESVILLE, VIRGINIA.	
University of Virginia	1
CHARLESTON, SOUTH CAROLINA.	
Elliott Society of Natural History	25
Society Library	1
South Carolina Historical Society	1
CAMBRIDGE, MASSACHUSETTS.	
American Association for Advancement of Science	28
Astronomical Journal	2
Harvard College	17
Museum of Comparative Zoology	21
Observatory of Harvard College	30
CANANDAIGUA, NEW YORK.	
Brigham Hall Asylum	1
CHICAGO, ILLINOIS.	
Chicago Academy of Science	44
Historical Society	1
Observatory	7
CINCINNATI, OHIO.	
Historical and Philosophical Society	3
Mercantile Library	1
Observatory	7
CLINTON, NEW YORK.	
Observatory of Hamilton College	4
COLUMBIA, SOUTH CAROLINA.	
South Carolina College	1
COLUMBUS, OHIO.	
Central Lunatic Asylum	1
Ohio State Board of Agriculture	64
CONCORD, NEW HAMPSHIRE.	
New Hampshire Asylum	1
New Hampshire Historical Society	2
DANVILLE, KENTUCKY.	
Institution for Deaf and Dumb	1
DES MOINES, IOWA.	
Governor of the State of Iowa	1
State Library	24
DAYTON, OHIO.	
Southern Lunatic Asylum	1
DETROIT, MICHIGAN.	
Historical Society	1
Michigan State Agricultural Society	10
FLATBUSH, NEW YORK.	
King's County Lunatic Asylum	1
FRANKFORD, PENNSYLVANIA.	
Asylum for Insane	1
FRANKFORT, KENTUCKY.	
Geological Survey of Kentucky	6
FULTON, MISSOURI.	
State Lunatic Asylum	1
GAMBIER, OHIO.	
Kenyon College	1
GEORGETOWN, D. C.	
Georgetown College	13
HALIFAX, NOVA SCOTIA.	
Nova Scotian Institute of Natural Sciences	1
HANOVER, NEW HAMPSHIRE.	
Dartmouth College	1
HARRISBURG, PENNSYLVANIA.	
State Library	1
State Lunatic Hospital	1
HARTFORD, CONNECTICUT.	
American Institution for Deaf and Dumb	1
Historical Society	1
Retreat for Insane	1
Trinity College	1
Young Men's Institute	1
HOPKINSVILLE, KENTUCKY.	
Western Lunatic Asylum	1

Packages received by Smithsonian Institution, &c.—Continued.

	No. of packages.
IOWA CITY, IOWA.	
State University	35
JACKSON, LOUISIANA.	
Insane Asylum	1
JACKSONVILLE, ILLINOIS.	
Institution for the Blind	1
JANESVILLE, WISCONSIN.	
Institution for Blind	5
JEFFERSON CITY, MISSOURI.	
Governor of the State of Missouri	1
KINGSTON, JAMAICA.	
Jamaica Society of Arts	1
LEXINGTON, KENTUCKY.	
Eastern Lunatic Asylum	1
LITTLE ROCK, ARKANSAS.	
State Library	41
State University	4
MADISON, WISCONSIN.	
Emigration Bureau	1
State Historical Society of Wisconsin	8
State Library	6
State University	1
Wisconsin Natural History Society	1
Wisconsin State Agricultural Society	17
MILL CREEK, OHIO.	
Hamilton County Lunatic Asylum	1
MONTPELIER, VERMONT.	
Historical Society of Vermont	1
State Library	2
MONTREAL, CANADA.	
Natural History Society	8
MOUNT PLEASANT, IOWA.	
Wesleyan University	1
NASHVILLE, TENNESSEE.	
Hospital for Insane	1
NEWARK, NEW JERSEY.	
Historical Society of New Jersey	1
NEWBURG, OHIO.	
Northern Lunatic Asylum	1
NEW HAVEN, CONNECTICUT.	
American Journal of Science and Art	54
American Oriental Society	25
Connecticut Academy of Sciences	1
Yale College	14
NEW ORLEANS, LOUISIANA.	
New Orleans Academy of Sciences	35
NEW YORK, NEW YORK.	
American Christian Commission	12
American Ethnological Society	14
American Geographical and Statistical Society	54
American Institute	9
Astor Library	5
Bloomingdale Asylum for Insane	1
Courier des Etats Unis	1
Historical Society	2
Mercantile Library Association	2
New York Academy of Medicine	5
New York Christian Enquirer	5
New York Institution for Blind	1
New York Institution for Deaf and Dumb	1
New York Lyceum of Natural History	96
School of Mines	3
United States Sanitary Commission	14
University	5
PHILADELPHIA, PENNSYLVANIA.	
Academy of Natural Sciences	201
American Journal of Conchology	2
American Entomological Society	5
American Pharmaceutical Associat'n	27
American Philosophical Society	99
Central High School	4
Central High School Observatory	1
Franklin Institute	25
Girard College	1
Historical Society of Pennsylvania	5
Library Company	2
Medical and Chirurgical Review	1
Naval Review	1
Pennsylvania Horticultural Society	2
Pennsylvania Hospital for Insane	1
Pennsylvania Institute for Blind	2
Pennsylvania Institute for Deaf and Dumb	1
Wagner Free Institute	7

Packages received by Smithsonian Institution, &c.—Continued

	No. of packages.
PITTSBURG, PENNSYLVANIA.	
Western Pennsylvania Hospital	1
PORTLAND, MAINE.	
Portland Society of Natural History	24
PRINCETON, NEW JERSEY.	
College of New Jersey	1
PROVIDENCE, RHODE ISLAND.	
Brown University	1
Butler Hospital for Insane	1
Rhode Island Historical Society	1
Secretary of State	1
QUEBEC, CANADA.	
Literary and Historical Society	1
Observatory	1
RALEIGH, NORTH CAROLINA.	
Insane Asylum	1
RICHMOND, VIRGINIA.	
State Library	1
SACRAMENTO, CALIFORNIA.	
State Agricultural Society	1
ST. JOHN'S, NEW BRUNSWICK.	
Natural History Society of New Brunswick	1
ST. LOUIS, MISSOURI.	
St. Louis Academy of Sciences	115
Slavni Redakei Pozom	1
University	2
ST. PAUL, MINNESOTA.	
Historical Society	3
SALEM, MASSACHUSETTS.	
Essex Institute	10
SAN FRANCISCO, CALIFORNIA.	
California Academy of Natural Sciences	51
Observatory	1
SOMERVILLE, MASSACHUSETTS.	
McLean Insane Asylum	1
STAUNTON, VIRGINIA.	
Western Lunatic Asylum	1
TRENTON, NEW JERSEY.	
State Lunatic Hospital	1
TORONTO, CANADA.	
Canadian Institute	5
Observatory	3
UTICA, NEW YORK.	
American Journal of Insanity	1
New York State Lunatic Asylum	1
WASHINGTON, D. C.	
American Nautical Almanac	4
Bureau of Navigation	2
Bureau of Statistics	4
Census Office	2
Commissioner for Indian Affairs	1
Library of Congress	7
Medical Department	45
National Academy of Sciences	24
Ordnance Bureau	7
Secretary of the Navy	1
Secretary of War	6
State Department	4
Treasury Department	2
United States Coast Survey	54
United States Department of Agriculture	2
United States Naval Observatory	103
United States Patent Office	149
War Department	3
Washington Public Schools	1
WEST POINT, NEW YORK.	
United States Military Academy	1
WILLIAMSBURG, VIRGINIA.	
Eastern Lunatic Asylum	2
WORCESTER, MASSACHUSETTS.	
American Antiquarian Society	7
State Lunatic Hospital	1
Total addresses of institutions. 197	
Total addresses of individuals. 150	
	347
Total number of parcels to institutions 2,356	
Total number of parcels to individuals 615	
	2,971

D.—*Copy of circular relative to exchanges of government documents.*

SMITHSONIAN INSTITUTION,
Washington, U. S. A., May 16, 1867.

A law has just been passed by the Congress of the United States authorizing the exchange, under direction of the Smithsonian Institution, of a certain number of all United States official documents for the corresponding publications of other governments throughout the world; the returns to be placed in the national library at Washington. The works to be distributed under this law will consist of reports and proceedings of Congress, messages of the President, annual reports and occasional publications of departments and bureaus, &c., the whole relating to the legislation, jurisprudence, foreign relations, commerce, statistics, arts, manufactures, agriculture, geography, hydrography, &c., of the United States, and including everything, of whatever nature, published, either by direct order of Congress or by any of the departments of the government. The series will embrace a large number of volumes each year, the most of which are bound.

The object of the law above mentioned is to procure for the use of the Congress of the United States a complete series of the publications of other governments, to include the documents of special bureaus or departments, as well as the general publications, of whatever nature, printed at the public expense, and also embracing all such works as are published by booksellers with the aid of grants or subscriptions from governments. The law is not retrospective, although it may cover some of the publications of the last session of Congress.

Some time will necessarily elapse before the first transmissions can be made; but in order to organize a plan of exchange, to be presented for consideration to the Library Committee and the librarian of Congress, I beg leave to ask your advice as to the best method of accomplishing the objects above stated. It is important to ascertain what governments are willing to enter into the proposed exchange, and whether any one bureau or branch of government or public library in each country will undertake to collect all the national publications, as above mentioned, and transmit them to Washington, or whether separate arrangements must be made with more than one office. The former plan is considered preferable, as diminishing the labor involved, and may possibly be adopted by enactment, as has been done by the United States. Whatever method be most feasible, you will confer a favor by giving us such information on these and other points as may serve for our guidance in further action.

Information is also desired as to the titles and character of the regular official publications of each country, and their average number and extent in each year, as well as the names of the different bureaus or offices from which they emanate.

The Smithsonian Institution, in behalf of the Library of Congress, is prepared to promise, if necessary, the delivery of the above-mentioned publications free of charge for freight. It will also name an agent in each country who will receive the parcels or boxes containing the exchanges returned, and transmit them to Washington.

Besides the exchange of complete series of national publications, the law of Congress above stated authorizes the distribution of works on special subjects to the different bureaus having them in charge, as finance, statistics, patents, agriculture, &c., provided that copies of their publications be given in return.

Very respectfully, your obedient servant,

JOSEPH HENRY,
Secretary Smithsonian Institution.

E.—*Table showing the entries in the record books of the Smithsonian Institution in* 1865, 1866, *and* 1867.

Class.	1865.	1866.	1867.
Skeletons and skulls	6,609	7,100	7,500
Mammals	8,416	8,685	8,900
Birds	40,554	45,000	50,000
Reptiles	6,544	6,582	7,150
Fishes	5,588	5,591	5,625
Eggs of birds	9,939	10,400	13,300
Crustaceans	1,287	1,287	1,287
Mollusks	18,103	18,500	18,500
Radiates	2,725	2,725	2,725
Annelides	110	110	110
Fossils	5,907	5,920	6,600
Minerals	4,940	4,941	5,150
Ethnological specimens	1,125	2,260	5,400
Plants	....	....	175
Total	111,847	119,101	132,322

F.—*Approximate table of distribution of duplicate specimens by the Smithsonian Institution to the end of* 1867.

Class.	Distribution to end of 1866.		Distribution to end of 1867.		Total.	
	Species.	Specimens.	Species.	Specimens.	Species.	Specimens.
Osteology	104	104	1	1	105	105
Mammals	794	1,574	14	14	808	1,588
Birds	8,079	12,286	1,358	2,293	9,437	14,579
Reptiles	1,641	2,609	21	106	1,662	2,715
Fishes	2,394	5,150	30	50	2,424	5,200
Eggs of birds	3,699	9,379	188	722	3,887	10,101
Shells	67,412	162,214	4,352	7,652	71,764	169,866
Radiates	551	727	....	....	551	727
Crustaceans	1,013	2,516	....	....	1,013	2,516
Marine invertebrates generally	1,838	5,152	....	....	1,838	5,152
Plants	13,058	18,303	300	400	13,358	18,703
Fossils	2,971	7,557	390	1,370	3,361	8,927
Minerals and rocks	1,346	5,579	372	480	1,718	6,059
Ethnology	150	150	898	898	1,048	1,046
Insects	....	....	1,190	1,937	1,190	1,937
Total	105,050	233,300	9,114	15,923	114,164	249,223

G.—ADDITIONS TO THE COLLECTIONS OF THE SMITHSONIAN INSTITUTION IN 1867.

Academy of Natural Sciences, Philadelphia.—Ten mounted birds, various localities.

Alibert, J. P., (per Hon. G. V. Fox, Assistant Secretary United States Navy.)—Mass of graphite mounted, with associated rocks and manufactured pencils, Eastern Siberia.

Ashcom, G. W.—Insect molluscs, reindeer horns, Plover bay.

Austin, E. P.—Three bottles of insects, near Mount Vernon, Virginia; 4 boxes of insects from Massachusetts.

Bannister, Henry M.—General collection natural history, St. Michael's, Norton sound.

Bartsch, Franz.—Collection of mosses and algæ, Austria.
Becker, Alexander and F. White.—Large stereoscope and views.
Bell, Hannah.—Indian stone relics, Allegany county, New York.
Bernay, Dr. F. T.—Collection of vegetable fibres, &c., Missouri.
Berthoud, Dr. E. L.—Fossils, Indian relics, &c., Colorado.
Brigham & Mann.—Series of corals, Sandwich Islands.
Bishop, N. H.—Skins and eggs of birds of Cuba.
Blackburn, Charles and George.—Collection of birds' eggs, Iowa.
Blake, W P.—Specimens of wool of mountain goat, Russian America.
Bland, Thomas.—Collection of reptiles, spiders, &c., Inagua; 90 species of land shells, America.
Boardman, G. A.—*Helminthophaga peregrina;* sterna of birds, skins, eggs, &c., Maine.
Bolander, Dr. H. N.—Collection of plants, California; eggs of *Grus canadensis,* Sierra Nevada, California.
Bond, Dr. Thomas J.—*Crotaphytus* in alcohol, Choctaw nation.
Brewer, Dr. T. M.—Types of eggs figured in North American oology, various.
Bryan, O. N.—Box bird skins, fossil bones, &c.; miocene fossils, Maryland.
Bulkeley, Colonel Charles S., (Robert H. Kennicott, William H. Dall, directors of scientific corps.)—28 boxes of collections of the Russian Overland Telegraph Expedition, in all branches of natural history, collected in part by Bischoff, at Sitka.
Burton, Hon. A. A.—General zoological collections, minerals, &c., Bogota; sulphate of barytes, Kentucky.
Butcher, Dr. H. B.—General collection of birds, fossils, mammals, Texas.
Caldwell, R.—Box shells, Chappell island and Plover bay.
Canfield, Dr. C. A.—Three boxes zoological specimens, California.
Carmiol, Julian.—Birds, 233 species, seeds of palms, &c.; mammals, shells, Costa Rica.
Christ, Richard.—Box of birds' eggs, Pennsylvania.
Clary Brothers.—Collection of birds' eggs, Illinois.
Cotter, B. A.—Birds' eggs, St. Michael's.
Cook, J. W.—Petrifaction.
Cooper, Dr. J. G.—Nests, eggs, birds, reptiles, shells, California.
Crocker, Allan.—Numerous birds' eggs, &c., Kansas.
Csapkay, L. J., U. S. consul.—Carved wooden box, tobacco pouch, child's coat, drinking cup, cane, Hungary.
Dall, W. H.—General collections, North Pacific ocean.
Davis, Henry.—Indian relics and river shells, Iowa.
Dayton, E. A.—Vertebræ of fossil saurian, opposite Aquia creek, Virginia.
Diehl, Israel S.—Wool of Angora goat raised in Ohio; casts of Assyrian seals.
Dow, Captain J. M.—Skin of tern, Veragua.
Edmonds, Hon. J. W.—Stone axe, ancient mines of Lake Superior.
Edwards, Daniel.—Indian stone relics, Genesee county, New York.
Endres, J. R.—Humming birds in skins and in alcohol, Costa Rica.
Fletcher, N.—Reindeer horns, Plover bay, Siberia.
Foreman, Dr. E.—*Scops asio,* (young,) Maryland.
Freeman, Professor.—Collection of reptiles, insects, vampire bat, living achatina, fibres of blood-root, &c., Liberia, Africa.
Fox, Hon. J. V., U. S. N.—Three boxes minerals and metallurgic specimens, Sweden.
Gibbs, George.—Specimens of limestone, Kansas.
Giraud, J. P.—Types of "16 new species of Texas birds," Texas.
Glasco, J. M.—Grasshoppers, Texas.
Glover, Professor T.—Seeds of *Boehmeria nivea.*
Goulding, B. P.—Specimens of nickel and cobalt, Scotland.

Gray, Dr. C. C., U. S. A.—Six bottles insects, three boxes shells.
Gray, R. J.—Collection of birds from Mexico.
Grayson, Colonel A. J.—One box of birds, Mazatlan.
Green, Jasper.—Cast of fossil plant, Schuylkill county, Pennsylvania.
Green, T. H.—Indian stone relics, New York.
Gruber, F.—Box of birds, California.
Hague, Henry.—Bird skins, two skins of *Panyptila stihieronymi* and nest, small box river shells, Guatemala.
Haining, W. J.—Stone lamp, Plover bay.
Hall, C. F.—Eggs of snowy owl and pair of fur mittens, (Esquimaux,) Hudson's Bay.
Hardeman, George.—Box bird skins, San Salvador.
Harvey & Holden.—Specimens of varieties of *Ostrea virginca.*
Hayes, I. I.—Skeleton and skulls of walrus, North Greenland.
Hayden, Dr. F. V.—Fossils, rocks, &c., Nebraska.
Helper, H. R.—Bones of mastodon, fossil shells, Buenos Ayres.
Hepburn, J.—*Brachyramphus marmoratus* and four species of birds' eggs, Vancouver island.
Hitz, Dr. R. B.—One box of fossils, Iowa.
Hudson, W. H.—123 bird skins, Buenos Ayres.
Huson, Alden W.—Various zoological specimens presented through Colonel Bulkeley, mollusks and fishes, north end of Vancouver island.
Intertropical Company, New York.—Specimens of fibres and nuts.
Irwin, Dr. B. J. D.—16 bottles reptiles, &c., New Mexico.
Jones, Strachan.—Birds' eggs and skins, Indian satchel, Fort Rae.
Kelsey, Captain W. H.—Wooden plate of natives, Plover bay.
Kennedy, J. C. G.—Snake and dried plant, Maryland.
Ketchum, Frank.—Skulls of Indians, &c., Yukon.
King, Clarence.—Two boxes zoological and geological specimens, Nevada.
Kircheval, A. W.—Rock specimens, &c., Virginia.
Kjerulf, Professor H.—Minerals, fossils, rocks, Norway.
Kluge, Dr. J. P.—Collection of fishes and *Didelphys quica* and young, in alcohol, Aspinwall.
Krider, J.—25 mounted birds, various.
De Lacerda, A.—Collection of birds, Brazil.
Lahmann, F.—Box of minerals and fossils, Costa Rica.
Latimer, George.—Four jars crabs, crows, snake, Porto Rico.
Leacock, B. B.—Two bird skins, Trinidad.
Lemon, W. C.—Skull of mountain sheep, Kamtschatka.
Lewers, Lydia.—Arrow-heads, Iowa.
Lewis, Dr. James.—Box small land and fresh-water shells, New York.
Lincecum, Dr. Gideon.—Box of cretaceous fossils, shells, &c.; insects and alcoholic preparations, from western Texas.
Lincecum, Lysander R.—Skulls of mammals, Texas.
Long, James H.—Living owl, District of Columbia.
Longsdorf, Henry A.—Black sand underlying Prairie Bluff, Missouri.
Lytle, W.—*Productus costatus*, Indiana.
McDonald, Prof. Marshall.—Box fossils, chert limestone; *Helicina occulta*, Say, Virginia.
Mapes, H. H.—Insects in alcohol, Michigan.
Merritt, John C.—Indian arrow-heads, iron ore, &c.
Minor, Dr. T. T.—One box Indian relics; skull of buffalo; Nebraska.
Morch, D.—*Cyprina islandica*, varieties, and other European shells; type specimens of a memoir on fresh-water and land shells of Greenland.
Moore, C. R.—Birds' eggs, Indian relics, Virginia.
Morgan, L. H.—Six skulls of beaver, Lake Superior.

Mudge, Prof. B. F.—Box of fossils, Kansas.
Naturhistorischer Verein, of 1854.—Specimens *lepidoptera*.
O'Donoghue, John O.—Dredgings of silt, St. Mary's river, Michigan.
Palmer, Dr. E.—Six boxes collections of natural history, Indian relics, &c., Arizona.
Parleman, Dr. W.—Stone axes, Iowa.
Parker, Dr.—Two boxes of specimens gray Medina sandstone, New York.
Parrish, John H.—Eggs of *Antrostomus Carolinensis*, Alabama.
Parsons, W. B.—Bat, in flesh, Kansas.
Patterson, F. A.—Stuffed skin of rattlesnake.
Peale, Franklin.—Photograph of Indian arrow-heads, Philadelphia.
Pease, Charles.—Zoological collections, Russian America.
Phillip, Dr. R. A.—338 specimens birds, Chile.
Poey, Prof. F.—Keg of fishes, Cuba.
Posten, Col. Charles D.—Playing cards of raw hide, made and used by the Coyotero Apaches in the game of monte, Arizona.
Potts, Dr. John G.—Box of shells and *Mergulus alle*, in flesh, Virginia.
Provancher M. Abbe.—Coleoptera, Canada.
Randal, F. O.—Many living specimens of *Menopoma Alleghaniensis*, Pennsylvania.
Rasin, R. W. L.—Three bottles reptiles, &c., Navassa island.
Reed, M. C.—Indian remains from a mound near Chattanooga.
Riecksecker, L. E.—Birds' eggs, Pennsylvania.
Ridgway, R.—Bird skins, skulls, eggs, skin of albino *Turdus migratorius*, Illinois.
Richardson, Mr.—Slag, from the conflagration of New York Crystal Palace, New York.
Riotte, Hon. C. N.—Five acorns evergreen oak, Costa Rica.
Rodifer, J.—Specimens of iron ore, Virginia.
Roessler, A. R.—Indian arrow-heads, New Mexico.
Rothrock, J. F.—Box of plants, Russian America; Indian relics, British Columbia.
Royal College of Surgeons, London.—Box of sterna of birds, Australia.
Ruyter, White De.—Mineral concretions and nodules, Indiana.
Russell, B. S.—Impressions of ferns in sandstone, Pennsylvania.
Salvin, Osbert.—Collection of birds, from Veragua.
Samuels, E. A.—Eggs of *Contopus borealis*, *Scops asio*, &c., Massachusetts.
Sawkins, J. G.—Foraminifera, in yellow limestone, Jamaica, West Indies.
Scammon, Captain.—Skeleton of seal, also plants, soundings, fishes, shells, Plover bay and Emma harbor.
Schuyler, T. J.—Lot of shells, Plover bay.
Schonborn, A.—Four bottles of reptiles, fish, insects, from Fort Laramie.
Schott, Dr. A.—Cotton from *Bombyx pentandra*, Yucatan; also, Yucatan lepidoptera.
Scott, Ansel.—Specimens of the wood of white-pine tree, long buried in swamps; also Indian arrow-head, Pennsylvania.
Shute, J. G.—Six sets birds' nests and eggs, Massachusetts.
Shimer, Prof. Henry.—Box bird-skins, Illinois.
Sigel, W. H., Director of Hamburg Zoological Garden.—Two cages, containing 300 *Passer domesticus*, (house sparrow;) 10 arrived living.
Smith, E. E.—Shells and plants, Puget sound and Plover bay.
Stearns, R. E. C.—Collection of shells, skull of panther, Pacific coast.
Sumichrast, Prof. F.—Collection of reptiles, fishes, and insects, in alcohol, Orizaba.
Swan, J. G.—Two boxes ethnological and zoological specimens, Puget sound.
Thompson, J. W.—*Montacuta Gouldii*, Thompson, Massachusetts.

Tolman, J. W.—Collection of birds' eggs, Illinois.
Townsend, W. A.—Star fishes, Plover bay.
Tripp, T. Martin.—Nest of *Empidonax minimus* and other eggs, New Jersey.
Tyler, Robert.—Box of minerals, shells, and marine invertebrates, Great Britain.
Van Tassel, I.—Skull of rabbit, &c., Behring straits.
Von Frantzius.—Skin of *Catharus*, Costa Rica.
Van Orman, J.—Indian pottery, Iowa.
Van Patten, Dr. C. H.—Birds and other collections, Guatemala.
Wakefield, Dr.—*Polioptila plumbea*, Sonora.
Walker, Dr. R. L.—Living *Menopamas* and *Trionix*, Pennsylvania.
Walton, Henry.—Tin ore, Missouri.
Warren, General G. K.—Box of ethnological collections and heads of antelope, upper Missouri.
Wheatley, Charles M.—Land and fresh-water univalves, America.
White, F.—See A. Becker.
Whymper, F.—Plants, Petropaulowski.
Williams, Dr. J. A.—Two boxes named fossils and shells, Missouri.
Wilson, D. S.—97 borings of artesian wells, Ohio.
Wood, Dr. W.—Birds' eggs, Connecticut.
Wright, Charles.—Birds and nests, Cuba.
Wright, Major G. M.—Tschuchtschi skulls, Plover bay.
Zoological Museum, Berlin.—Collection of *Ovis* and reptiles, Europe and Asia.

H.—*List of the Expeditions and other sources from which the specimens in the Government Museum have been mainly derived.*

1. United States Exploring Expedition, under Captain Wilkes, United States navy, 1838–'42. The collections made by this naval expedition are supposed greatly to exceed those of any other of similar character ever fitted out by any government; no published series of results comparing in magnitude with that issued under the direction of the Joint Library Committee of Congress. The collections made embrace full series of the animals, plants, minerals and ethnological materials of the regions visited, such as the coast of South America, the islands of the South seas, &c. The naturalists of the expedition were Titian R. Peale, J. D. Dana, Charles Pickering, W. Rich, J. P. Couthony, and W. D. Brackinridge.

2. Exploration of the Amazon and its tributaries in 1851–'52, by Lieutenant W. E. Herndon, United States navy. The collections made consist chiefly of vertebrate animals and ethnological material.

3. Exploration of the valley of Great Salt Lake, by Captain Stansbury, United States army, in 1851. Collections in character much like the last.

4. Explorations of the Zuni and Colorado rivers, by Captain Sitgreaves, United States army, in 1851 and 1852, and the survey of the Creek boundary and Canadian Fork of the Arkansas, in 1856, by Captains J. C. Woodruff and Sitgreaves, Dr. S. W. Woodhouse, naturalist.

5. Presents made to the United States by the King of Siam and other foreign governments, deposited by the State Department.

6. Exploration of Commodore M. C. Perry, United States navy, made while negotiating a treaty with Japan, and the presents to the United States government through him from the Japanese authorities.

7. From Dr. D. D. Owen in his United States geological explorations in the west.

8. Indian paintings from the War and Indian Departments.

9. United States geological survey made in Iowa, Illinois, and Minnesota, under Dr. D. D. Owen.

10. United States geological survey, made on Lake Superior by Messrs. Foster and Whitney.

11. Geological exploration made by Dr. Charles T. Jackson on Lake Superior.

12. Geological survey made in Oregon and Washington Territory by Dr. J. Evans.

13. The expedition to Chile under Lieutenant J. M. Gilliss, United States navy. Vertebrates and minerals.

14. North Pacific surveying and exploring expedition under Captains Ringgold and Rodgers, United States navy, chiefly in the China seas, Behring's straits, coast of California, &c., in 1853 to 1856; W. Stimpson and Charles Wright, principal naturalists.

15. The survey of the line between the United States and Mexico, first organized under Hon. J. B. Weller, as commissioner, and Major W. H. Emory, as chief of the scientific department; then under J. R. Bartlett, as commissioner, and Colonel J. D. Graham, chief of the scientific corps, succeeded subsequently by Major W. H. Emory; then under General R. B. Campbell, commissioner, and Major W. H. Emory, chief of the scientific corps; together with the survey of the boundary line of the Gadsden purchase, under Major W. H. Emory, commissioner, 1850 and 1856; collectors John H. Clark, Arthur Schott, C. C. Parry, Charles Wright, and Dr. T. H. Webb.

16. Pacific railroad survey, of the 38th, 39th, and 47th parallels, under Governor Stevens, in 1853–'54; Dr. George Suckley and J. G. Cooper, collectors.

17. Pacific railroad survey on the 38th, 39th and 41st parallels, under Captains J. W. Gunnison and E. S. Beckwith, in 1853 and 1854; Mr. F. Kreutzfeldt, principal collector.

18. Pacific railroad survey on the 35th parallel, under Captain Whipple, in 1853 and 1854; Drs. C. B. Kennerly, J. M. Bigelow, Jules Marcou, and H. B. Mollhausen, collectors.

19. Pacific railroad survey on the partial route in California, under Lieutenant Williamson, in 1853 and 1854; Dr. A. S. Heerman and W. P. Blake, collectors.

20. Pacific railroad survey on the western end of the 32d parallel, under Lieutenant Parke; in 1853–'54, Dr. A. S. Heerman and Dr. Antisell, collectors.

21. Pacific railroad survey, on the eastern end of the same parallel, under Captain Pope, in 1853.

22. Pacific railroad survey in California and Oregon, under Lieutenant Williamson, in 1855; Dr. J. S. Newberry, collector.

23. Expedition of Captain Pope to sink artesian wells on the Llano Estacado, in 1854, &c.; Dr. G. P. Shumard, geologist.

24. Northwestern boundary survey in 1857–'61, under A. Campbell, esq.; Dr. C. B. Kennerly and Geo. Gibbs, collectors.

25. Expedition of Captain Page, United States navy, in 1853 and 1856 to the Parana and its tributaries; Ed. Palmer, collector.

26. Expedition to the Isthmus of Darien, by Lieut. Michler, United States army, in 1857; Arthur Schott, aided by W. S. and Charles Wood, collectors.

27. Expedition of Lieutenant Bryan during two seasons spent in constructing a wagon road from Fort Riley to Bridger's pass, in 1856 and 1857; W. S. Wood, collector.

28. Expedition to upper Missouri and Yellowstone in 1856, under Lieutenant Warren; Dr. F. V. Hayden, collector.

29. Expedition to the Black Hills, Loup Fork of the Platte, in 1857–'58, by Lieutenant Warren; Dr. F. V. Hayden, collector.

30. Expedition to the Red river in 1852, by Captain Marcy; Captain G. B. McClellan, principal collector.

31. South Pass wagon road expedition, under W. M. Magraw, in 1857; Dr. J. G. Cooper and C. Drexler, collectors.

32. Exploration of the Colorado river, under Lieutenant Ives, in 1857; Dr. J. S. Newberry and H. B. Mollhausen, collectors.

33. Explorations in Kansas, Nebraska, and Utah, by Captain J. H. Simpson, United States army, in 1858–'59; Dr. G. Engelmann, geologist; C. S. McCarty, collector.

34. South Pass wagon road expedition in 1859, under F. W. Lander, esq., by Mr. Snyder.

35. El Paso and Fort Yuma wagon road expedition, under J. B. Leech, esq., in 1857–'58, by Dr. S. Hayes.

36. Wagon road expedition from Walla-Walla to Fort Benton, under Lieutenant John Mullan, United States army, in 1859; John Pearsall and Mr. Hildreth, collectors.

37. Exploration of the upper Missouri and Yellowstone, by Captain J. W. Raynolds, United States army, in 1859–'60; Dr. F. V. Hayden and Geo. H. Trook, collectors.

38. Exploration of the San Juan and upper Colorado, by Captain J. N. Macomb, United States army, in 1859; Dr. J. S. Newberry, collector.

39. Commodore Perry's Japan expedition, in 1854.

40. Exploration during the march of troops to Oregon, via Fort Benton, under Major J. H. Blake, in 1860, by Dr. J. G. Cooper.

41. Survey of the northern boundary of Texas in 1860, by Mr. J. H. Clarke; C. S. McCarthy, collector.

42. Exploration of the Dead sea, by Lieutenant W. F. Lynch:

43. Geological survey of Oregon in 1852, by Dr. J. Evans and B. F. Shumard.

44. Survey from the Missouri river to Los Angelos, via the Huerfano pass, in 1854, by Lieutenant E. F. Beale.

45. General Sully's expedition to the upper Missouri, &c., by S. M. Rothammer.

46. Artesian well expedition to the Llano Estacado of Texas, in 1857, by Captain John Pope.

47. Explorations of the Brazos and Wichita rivers, in 1854, by Captain R. B. Marcy; Dr. G. C. Shumard, naturalist.

48. Journey from Chile to Buenos Ayres, by Lieutenant A. McRae, United States navy, in connection with Captain Gilliss's expedition, in 1853 and 1854.

49. Survey of the southern boundary of Kansas, under Lieutenant Colonel J. S. Johnston, in 1857; collections made by J. H. Clark.

50. Exploration of the La Plata river and its tributaries in 1857 and 1860, by Captain T. J. Page, United States navy; Chris. Wood, collector.

51. Exploration of Russian America, under the direction of Captain W. A. Howard, United States revenue service, in 1867, in the steamer Lincoln.

52. Exploration of Russian America, under the direction of Geo. B. Davidson, of the United States coast survey, in 1867.

53. Exploration by the War Department of the region along the 40th parallel, under Clarence King.

LIST

OF

METEOROLOGICAL STATIONS AND OBSERVERS OF THE SMITHSONIAN INSTITUTION FOR THE YEAR 1867.

B signifies Barometer, P, Psychometer; T, Thermometer; R, Rain gauge; A, All four instruments; N, No instrument.

BRITISH AMERICA.

Name of observer.	Station.	North latitude.	West longitude.	Height.	Instruments.	No. of months received.
		° ′	° ′	*Feet.*		
Acadia College	Wolfville, Nova Scotia	45 06	64 25	80	A	11
Jones, W. Martin	Clifton, Canada West				T	6
Murdock, G	St. John, New Brunswick	45 16	66 03	135	A	12
O'Donoghue, John	St. Anne, Canada East	47 24	70 05	175	B. P. T	4

MEXICO.

Sartorius, Dr. Charles	Mirador, Vera Cruz	19 15	96 25	3,600	A	12

CENTRAL AMERICA.

Frantzius, Dr. A	San José, Costa Rica	9 54	84 06	3,772	T. P	1
Klugé, J. P., M. D.; Rücker, G. A., M. D	Aspinwall	9 23	79 53	6	A	11

BERMUDA.

Royal Engineers, (in the Royal Gazette.)	Centre Signal Station, St. George's				A	12

ALABAMA.

Name of observer.	Station.	County.	North latitude.	West longitude.	Height.	Instruments.	No. of months received.
			° ′	° ′	*Feet.*		
Alison, H. L., M. D	Carlowville	Dallas	32 10	87 15	300	T. R	12
Henderson, William	Prairie Bluff	Wilcox	32 08	87 33		T	10
Peters, Thomas M	Moulton	Lawrence	34 36	87 25	643	B. T. R	12
Reynolds, R. M	Prairie Bluff	Wilcox	32 08	87 33		T	1
Shields, J. H	Opelika	Lee	32 35	85 30		T	10
Tutwiler, H	Havana	Greene	32 50	87 46	500	T. R	12
Vankirk, W. J	Bon Secour	Baldwin				T	8

List of meteorological stations and observers, &c.—Continued.

Name of observer.	Station.	County.	North latitude.	West longitude.	Height.	Instruments.	No. of months received.
			° ′	° ′ ″	*Feet.*		
ARKANSAS.							
Russell, O. F	Helena	Phillipps	34 33	90 10	....	T. R	3
Springer, Rev. Francis	Fort Smith	....	35 23	94 29	460	T	3
CALIFORNIA.							
Ayres, W. O., M. D	San Francisco	San Francisco	37 48	122 27	30	A	6
Canfield, Colb't A., M. D	Monterey	Monterey	36 36	121 52	40	A	12
Logan, Thos. M., M. D	Sacramento	Sacramento	38 32	121 30	65	A	3
Rogers, Francis M	Marsh's Ranch	Contra Costa	....	....	....	T	6
Trivett, Walter M	Stockton	San Joaquin	37 57	121 14	....	B. P	2
COLORADO.							
Berthoud, E. L	Golden City	....	39 44	105 08	5,242	T	4
Merriam, Arthur M	Fountaine	El Paso	....	....	....	N	1
CONNECTICUT.							
Dewhurst, Rev. E	Groton	New London	41 21	72 12	20	B. T. R	10
Hunt, Rev. Daniel	Pomfret	Windham	41 52	72 10	587	A	12
Johnston, Prof. John	Middletown	Middlesex	41 33	72 39	175	A	12
Rockwell, Charlotte	Colebrook	Litchfield	42 00	73 03	....	T	12
Williams, Rev. R. G	Waterbury	New Haven	41 33	73 02	....	B. T. R	9
Yeomans, William H	Columbia	Tolland	41 40	72 42	....	T	12
DELAWARE.							
Vankekle, L	Delaware City	New Castle	39 35	75 34	....	T	3
FLORIDA.							
Andrus, Wm. C	Cedar Keys	Levy	29 06	83 03	18	T	1
Baldwin, A. S., M. D	Jacksonville	Duval	30 15	82 00	20	A	11
Corey, Henry M	Fernandina	Nassau	30 31	81 30	25	T. R	7
Fisher, Galen M	Lake City	Columbia	30 12	82 40	135	T. R	1
Hawks, J. M., M. D	Port Orange	Volusia	....	....	....	T	12
Scott, H. B	Gordon	Alachua	29 45	82 30	....	T	8
GEORGIA.							
Deckner, Fredrick	Atlanta	Fulton	33 45	84 31	1,050	T. R	4
ILLINOIS.							
Adams, W. H	Elmore	Peoria	40 56	90 04	612	R	10
Aldrich, Verry	Tiskilwa	Bureau	41 15	89 16	550	T	12
Babcock, E	Riley	McHenry	42 11	88 33	760	T. R	2
Bowman, E. H., M. D	Andalusia	Rock Island	41 30	....	....	B. T	11
Ballou, N. E., M. D	Sandwich	De Kalb	41 31	88 30	665	T. R	12
Brendel, Frederick, M. D	Peoria	Peoria	40 43	89 30	460	A	12
Blanchard, O. A	Elmira	Stark	41 12	90 15	....	T. R	12
Brinkerhoff, Geo. M	Springfield	Sangamon	39 48	89 33	....	T	12
Brookes, Samuel	Chicago	Cook	42 00	87 30	600	T	11
Carey, Daniel	Alto	Lee	41 45	89 00	....	T	12
Dudley, Timothy	Waverly	Morgan	39 40	90 00	680	T. R	10

List of meteorological stations and observers, &c.—Continued

ILLINOIS—Continued.

Name of observer.	Station.	County.	North latitude.	West longitude.	Height.	Instruments.	No. of months received.
			° ′	° ′	*Feet.*		
Duncan, Rev. Alexander	Mount Sterling	Brown	40 00	91 15	....	T	12
Eldredge, Wm. V	Golconda	Pope	37 41	88 47	....	T	12
Freeman, H. C	South Pass	Union	....	....	....	T	5
Grant, John Grant, Charles W	Manchester	Scott	39 31	90 34	683	A	12
Huse, Fred. J	Evanston	Cook	42 03	87 38	614	B. T	1
Künster, H	Waterloo	Monroe	....	....	....	T	12
Langguth, John G., jr	Chicago	Cook	42 00	87 30	600	B. T. R	12
Little, Joseph T	Dixon	Lee	41 45	89 36	....	T	4
Livingston, Prof. Wm	Galesburg	Knox	40 55	90 25	795	A	12
Mead, S. B	Augusta	Hancock	40 10	91 00	....	T. P. R	12
Merwin, Mrs. Emily H	Ottawa	La Salle	41 20	88 47	500	T. R	12
Phelps, E. S. Phelps, Miss Lelia E	Wyanet	Bureau	41 30	89 45	....	T. R	12
Smith, Henry K	Magnolia	Putnam	41 15	89 15	....	T. R	6
Spencer, Wm. C	Dubois	Washington	38 14	89 16	....	T. R	11
Spaulding, Abiram	Aurora	Kane	41 48	88 23	....	A	12
Thompson, A. H	Lacon	Marshall	....	....	....	T. R	2
Tolman, James W	Winnebago	Winnebago	42 17	89 12	900	A	12

INDIANA.

Name of observer.	Station.	County.	North latitude.	West longitude.	Height.	Instruments.	No. of months received.
Boerner, Charles G	Vevay	Switzerland	38 46	84 59	....	T. R	11
Butterfield, W. W. & Mrs.	Indianapolis	Marion	39 45	86 20	698	T	10
Chappellsmith, John	New Harmony	Posey	38 08	87 50	350	A	11
Crosier, Dr. E. S	New Albany	Floyd	38 02	85 32	353	A	3
Dawson, Wm	Spiceland	Henry	39 48	85 18	1,025	B. T. R	12
Estun, W. J	Indianapolis	Marion	39 47	87 06	698	A	4
Holmes, Thomas	Merom	Sullivan	39 05	87 40	....	T. R	12
Kemper, G. W. H., M. D	Muncie	Delaware	40 12	85 16	....	T. R	11
Loughridge, Dr. J. H	Rensselaer	Jasper	40 56	87 13	745	T. R	5
McCoy, Dr. F McCoy, Miss Lizzie	Columbia City	Whitney	41 10	85 30	....	T. R	11
Sutton, George, M. D	Aurora	Dearborn	39 04	84 54	*80	B. T. R	12
Valentine, John	Richmond	Wayne	39 52	84 39	850	A	12

IOWA.

Name of observer.	Station.	County.	North latitude.	West longitude.	Height.	Instruments.	No. of months received.
Atkinson, Wm. O	Dakota	Humboldt	42 40	94 00	....	T	9
Babcock, E	Boonsboro'	Boone	42 00	93 14	....	T	2
Bryant, A. F	Fontanelle	Adair	41 28	94 30	1,500	T. R	12
Bush, Rev. Alva	Osage	Mitchell	43 20	83 00	....	T	2
Carpenter, B	Atalissa	Muscatine	41 32	91 12	....	T. R	5
Collin, Prof. Alonzo	Mount Vernon	Linn	42 00	91 00	....	T	12
Deering, D. S	Independence	Buchanan	42 30	92 16	850	T	4
Dickinson, James P	Guttenburg	Clayton	43 00	90 50	690	T	12
Dorweiler, Philip	Algona	Kossuth	....	....	....	T	12
Farnsworth, P. J., M. D	Clinton	Clinton	40 40	90 10	630	T. R	11
Hagensick, John Mathias	Ceres	Clayton	42 45	91 11	825	T	12
Horr, Asa, M. D	Dubuque	Dubuque	42 30	90 40	666	A	12
Hudson, A. T	Lyons	Clinton	40 42	90 10	630	T. R	5
Jorgenson, C. N	Fort Dodge	Humboldt	42 30	94 00	....	T	12
Love, Mrs. Louisa P	Burlington	Des Moines	40 53	91 10	530	T	1
McCready, Daniel	Fort Madison	Lee	40 37	91 28	....	T. R	12
Moulton, M. M	Monticello	Jones	42 15	91 15	800	T. R	12
Nash, Rev. J. A	Des Moines	Polk	41 35	93 36	....	T. R	3
Parvin, Prof. Theodore S	Iowa City	Johnson	41 37	....	621	A	12
Sheldon, D. S	Davenport	Scott	41 30	90 40	737	A	12
Steed, T	Waterloo	Black Hawk	42 30	92 30	670	T	12
Stern, Jacob T	Harris Grove	Harrison	41 00	95 00	900	T	12
Townsend, Nathan	Iowa Falls	Hardin	42 32	93 20	....	T. R	9
Wadey, H	Marble Rock	Floyd	43 00	93 00	....	T	8
Walton, Josiah P	Muscatine	Muscatine	41 25	92 02	582	A	12
Warne, George, M. D	Independence	Buchanan	42 25	92 06	850	B. T. R	8
Warren, James H	Algona	Kossuth	43 05	94 15	....	T. R	9
Wheaton, Mrs. Daniel D	Independence	Buchanan	42 29	91 50	....	T. R	11
Witter, David R	Whitesboro'	Harrison	41 38	95 40	....	T	1

*Above low water in the Ohio river.

List of meteorological stations and observers, &c.—Continued.

KANSAS.

Name of observer.	Station.	County.	North latitude.	West longitude.	Height.	Instruments.	No. of months received.
			° ′	° ′	*Feet.*		
Agricultural College	Manhattan	Riley	39 12	96 40	1,300	T. R	12
Beckwith, W	Olatha	Johnson	38 50	94 30		T. R	12
Hollingworth, Geo. W	Lawrence	Douglas	38 37	95 10	950	T. R	2
Horn, Dr. H. B. Horn, Miss Clotilde	Atchison	Atchison	39 42	95 00	1,000	T	12
Ingraham & Hyland	Baxter Springs	Cherokee				T. R	6
Shoemaker, J. G	Le Roy	Coffey	38 06	95 03		B. T. R	5
Stayman, Dr. J	Leavenworth	Leavenworth	39 15	94 52		T. R	12
Walters, Dr. James	Holton	Jackson	39 27	95 10	1,172	T	8
Woodworth, Abner, M. D	Council Grove	Morris	38 42	96 32		T. R	12

KENTUCKY.

Beatty, O	Danville	Boyle	37 40	84 30	900	B. T. R	7
Martin, Dr. Samuel D	Chilesburg	Fayette	38 04	84 20	983	B. T. R	12
Young, Mrs. Lawrence	Louisville	Jefferson	38 07	85 24	570	A	12

LOUISIANA.

Carter, J. H	Benton	Bassin				T	8
Foster, Robert W	New Orleans	Orleans	29 57	90 00		B. T	8
Teele, Rev. Albert K	Vidalia Plantat'n	Concordia	32 00	91 30		T	3

MAINE.

Eaton, Virgil G	North Prospect	Waldo	44 28	68 58	207	T	2
Gardiner, Robert H	Gardiner	Kennebec	44 11	69 46	76	A	12
Guptill, G. W	Cornish	York	43 40	70 44	800	T. R	12
Moore, Asa P	Lisbon	Androscoggin	44 00	70 04	130	T. R	12
Moulton, John P	Standish	Cumberland	43 45	70 30	280	T. R	8
Parker, J. D	Steuben	Washington	44 31	67 57	50	A	12
Pettingill, Waldo	Rumford Point	Oxford	44 30	70 40	600	T. R	8
Pitman, Edwin	Williamsburg	Piscataquis	45 21			T. R	7
Robinson, Almon	Webster	Androscoggin	44 04	70 04		T	4
Towle, Benjamin H	Lee	Penobscot				T. R	10
West, Silas	Cornish	York	43 40	70 44	784	A	12
Wilbur, Benjamin F	West Waterville	Kennebec	44 30	69 45	250	T. R	12

MARYLAND.

Goodman, Wm. R	Annapolis	Anne Arundel	38 58	76 29	20	A	12
Grape, George S	Catonsville	Baltimore	39 17	76 42	42	T	11
Jourdan, Prof. C. H	Emmittsburg	Frederick	39 40	77 21		T. R	4
McCormick, James O	Woodlawn	Cecil	39 39	76 04		B. T. R	12
Smith, Eli	Emmittsburg	Frederick				T	12
Stevenson, Rev. James	St. Inigoes	St. Mary's	38 10	76 30	45	A	8

MASSACHUSETTS.

Astronomical Observatory	Williamstown	Berkshire	42 43	73 13	686	A	12
Bacon, William	Richmond	Berkshire	42 13	72 20	1,000	T. R	11
Bixby, John H	West Newton	Middlesex	42 21	71 17	40	T	10
Caldwell, John H	Newbury	Essex	42 45	70 55	25	T	12
Cunningham, George A	Lunenburg	Worcester	42 35	71 43		B. T	12
Draper, Joseph	Worcester	Worcester	42 16	71 48	528	A	12
Fallon, John	Lawrence	Essex	42 42	71 11	133	A	12
Merriam, Sidney A	Topsfield	Essex	42 38	70 57		A	12
Metcalf, John George	Mendon	Worcester	42 06	71 34		B. T. R	12

List of meteorological stations and observers, &c.—Continued.

MASSACHUSETTS—Continued.

Name of observer.	Station.	County.	North latitude.	West longitude.	Height.	Instruments.	No. of months received.
			° ′	° ′	*Feet.*		
Nason, Rev. Elias	North Billerica	Middlesex	42 34	71 16		B. T	12
Nelson, Henry M	Georgetown	Essex	42 42	71 00	225	T	3
Nelson, S. Augustus	Georgetown	Essex	42 42	71 00	225	T	8
Newcomb, Guilford S	Kingston	Plymouth	42 00	70 45		T. R	12
Rodman, Samuel	New Bedford	Bristol	41 39	70 56	90	A	12
Snell, Prof. E. S	Amherst	Hampshire	42 22	72 34	267	A	12
Teele, Rev. Albert K	Milton	Norfolk				T	8
Tucker, Edward T	New Bedford	Bristol	41 39	70 55	50	T. R	8

MICHIGAN.

Name of observer.	Station.	County.	North latitude.	West longitude.	Height.	Instruments.	No. of months received.
Bullard, Ransom	Litchfield	Hillsdale	42 01	84 46	1,040	T. R	11
Chase, Milton, M. D	Kalamazoo	Kalamazoo				T	11
Ellis, Edwin, M. D	Ontonagon	Ontonagon	46 40	90 00	610	T	12
Holmes, E. S	Grand Rapids	Kent	43 00	85 40	752	T	11
Kedzie, Prof. R. C	Lansing	Ingham	42 42	84 34	895	A	11
Mapes, Henry H	Oshtemo	Kalamazoo				N	12
Paxton, John W	Alpena	Alpena	45 02	83 05	574	B. T	5
Smith, Rev. George N	Northport	Leelanaw	45 08	85 41	592	T	12
Smith, Harmon M	Kalamazoo	Kalamazoo	42 20	85 44		N	5
Steele, George E	Homestead	Benzie	44 30	86 00		T	3
Streng, L. H	Holland	Ottawa	42 42	86 00		T. R	9
Whelpley, Miss Florence E.	Monroe	Monroe	41 58	83 23	590	T. R	11
Whittlesey, S. H	Central Mine	Keweenaw	47 00	87 54	1,177	T	8

MINNESOTA.

Name of observer.	Station.	County.	North latitude.	West longitude.	Height.	Instruments.	No. of months received.
Babcock, Dr. B. F	Afton	Washington	44 50	93 00	950	T	5
Bardon, Richard	Grand Portage	Lake	47 50	89 50	612	T	5
Cheney, William	Minneapolis	Hennepin	45 00	93 10	856	A	12
Heimstreet, John W	St. Paul	Ramsey	44 57	93 05	800	A	1
Paterson, Rev. A. B., D. D	St. Paul	St. Paul	44 57	93 05	800	T. R	12
Roos, Charles	New Ulm	Brown	44 16	94 26	*821	T. R	12
Stephens, Prof. A. M	Red Wing	Goodhue	44 35	92 30	800	T. R	8
Wieland, C	Beaver Bay	Lake	47 12	91 18	650	T. R	12
Woodbury, C. W	Sibley	Sibley	44 31	94 26	1,000	T. R	12

MISSISSIPPI.

Name of observer.	Station.	County.	North latitude.	West longitude.	Height.	Instruments.	No. of months received.
Cleland, Rev. T. H	Fayette	Jefferson				T	12
McCary, William	Natchez	Adams	31 34	91 25		B. T. R	12
Moore, Albert	Grenada	Yallobusha	33 45	90 00		T	11
Smith, J. Edwards	Kingston	Adams	31 24	91 16		B. T	4

MISSOURI.

Name of observer.	Station.	County.	North latitude.	West longitude.	Height.	Instruments.	No. of months received.
Christian, John	Harrisonville	Cass	38 40	94 30		T. R	12
Englemann, George, M. D.	St. Louis	St. Louis	38 37	90 15	481	A	2
Fendler, Augustus	Allenton	St. Louis	38 29	90 45	482	B. T. P	12
Kaucher, William	Oregon	Holt	39 59	95 10	1,100	T. R	12
Moore, Miss Belle	Union	Franklin	38 25	91 09	616	T. R	6
	Hermitage	Hickory	37 56	93 16		T. R	4
Ray, George P	Canton	Lewis	40 12	91 37		T	7
Ruggles, Homer	Rolla	Phelps	37 58	91 33		T	8
Stuntebeck, Rev. F. H., S. J.	St. Louis	St. Louis	38 37	90 15	470	A	12
Vertrees, John E	Edinburg	Grundy	40 00	93 30		T. R	1

* Above Minnesota river.

List of meteorological stations and observers, &c.—Continued.

MONTANA.

Name of observer.	Station.	County.	North latitude.	West longitude.	Height.	Instruments.	No. of months received.
			° ′	° ′	*Feet.*		
Lehman, Dr. H. M	Camp Cooke		48 00	111 00		P. T. R.	1
Wheaton, Alex. Camp	Helena City	Edgerton	46 45	111 50	4,150	T	4

NEBRASKA.

Name of observer.	Station.	County.	North latitude.	West longitude.	Height.	Instruments.	No. of months received.
Bowen, John S	Elkhorn City	Washington	41 22	96 12	1,350	T	12
Brown, H. H	Dakota City	Dakota	42 30	96 30		T	3
Child, A. L., M. D	Glendale	Cass	40 55	96 05	1,010	T	12
Hamilton, Rev. Wm	Bellevue	Sarpy	41 08	95 50		T. R	5
	Blackbird Hills	Burt	42 10	96 00		T. R	4
McKenzie, J. M	Peru	Nemeha	40 29	95 46		T	1
Seltz, Charles	De Soto	Washington	41 30	96 00		T	12

NEW HAMPSHIRE.

Name of observer.	Station.	County.	North latitude.	West longitude.	Height.	Instruments.	No. of months received.
Brewster, Alfred	Tamworth	Carroll	43 50	71 19		T	2
Brown, Branch	Stratford	Coos	44 40	71 07	1,000	T. R	12
Chase, Arthur	Claremont	Sullivan	43 22	72 21	539	B. T. R.	12
Hatch, John	Portsmouth	Rockingham	43 05	70 41	12	A	11
Hurlin, Rev. William	Antrim	Hillsboro'				N	11
Mead, Stephen O	Claremont	Sullivan				T	1
Odell, Fletcher	Shelburne	Coos	44 23	71 06	700	B. T	8
Pitman, Charles H	North Barnstead	Belknap	43 38	71 27		T. R	12
Wheeler, John T	Concord	Merrimack	43 12	71 29	400	B. T. R.	6

NEW JERSEY.

Name of observer.	Station.	County.	North latitude.	West longitude.	Height.	Instruments.	No. of months received.
Beans, Thomas J	Moorestown	Burlington	39 59	74 54		T. R	10
Brooks, William	Paterson	Passaic	40 55	74 10	60	T. R	12
Cole, Barker	Seaville	Cape May	39 20	74 40	18	T. R	10
Cook, Ephraim R	Trenton	Mercer	40 14	74 46	60	B. T. R.	12
Cook, Prof. George H	New Brunswick	Middlesex	40 30	74 27	80	A	12
Couch, E. D	Newfield	Gloucester	39 30	74 50	180	T	3
Deacon, John C	Burlington	Burlington	40 05	75 10	60	T. R	12
Fleming, John	Readington	Hunterdon	40 33	74 40		T	8
Fritts, J. S	Elwood	Atlantic				T	2
Ingram, John, M. D	Vineland	Cumberland	39 38	75 00		A	5
Rhees, Morgan J., M. D	Mount Holly	Burlington	40 00	74 47	30	B. T	12
Sheppard, Clarkson Sheppard, Miss R. C	Greenwich	Cumberland	39 20	75 25	30	A	12
Shriver, Howard	Dover	Morris	40 54	74 35	652	B. P. T	12
Whitehead, W. A	Newark	Essex	40 45	74 10	35	B. T. R.	12
Wood, Samuel	Haddonfield	Camden			74	A	12

NEW YORK.

Name of observer.	Station.	County.	North latitude.	West longitude.	Height.	Instruments.	No. of months received.
Arden, Thomas B	Garrison's	Putnam	41 22	74 02	180	T. R	12
Aubier, Rev. Jno. M., S. J.	New York	New York	40 44	73 59	104	B. T	9
Barrows, Storrs	South Trenton	Oneida	43 10	74 56	835	T. R	12
Bartlett, Erastus B	Vermillion	Oswego	43 26	77 26	327	T. R	11
Beauchamp, William M	Skaneateles	Onondaga	43 00	76 30	932	B. T	5
Bowman, John	Baldwinsville	Onondaga	43 04	76 41		T	5
Bussing, D. S	Minaville	Montgomery	42 54	74 15		T	5
Bussing, John W	Minaville	Montgomery	42 54	74 15		T	1
Dewey, Prof. Chester	Rochester	Monroe	43 07	77 51	516	B. T. R.	11
Edwards, Daniel	Little Genesee	Allegany	42 00	78 36	1,500	B. T. R.	12
Fries, George W	Friendship	Allegany	42 15	78 10	1,536	T	9
Gardiner, James H	Newburg	Orange	41 31	74 01	85	B. T. R.	12
Gregory, S. O	Theresa	Jefferson	44 12	75 48	365	T. R	12
Haas, Henry	Depauville	Jefferson	44 15		350	T. R	12
Heimstreet, John W	Troy	Rensselaer	42 44	73 40	58	A	9

List of meteorological stations and observers, &c.—Continued.

NEW YORK—Continued.

Name of observer.	Station.	County.	North latitude.	West longitude.	Height.	Instruments.	No. of months received.
			° ′	° ′	*Feet.*		
Hillier, Spencer L	Stapleton	Richmond	40 39	74 04	50	A	3
Howell, Robert	Nichols	Tioga	42 00	76 32	....	T	12
Ingalsbe, Grenville M	South Hartford	Washington	43 15	73 21	400	T. R	11
Ives, William	Buffalo	Erie	42 50	78 56	600	B. T. R	12
Joy, Prof. Charles A	New York	New York	40 43	74 05	....	A	12
Mack, Rev. Eli T	Flatbush	Kings	40 37	74 02	54	B. T. R	11
Malcolm, Wm. Schuyler	Oswego	Oswego	43 28	76 30	250	B. T. R	12
Mathews, M. M., M. D	Rochester	Monroe	43 08	77 51	525	A	10
Morris, Miss Elizabeth	Throg's Neck	Westchester	40 49	73 49	43	T	12
Morris, Prof. Oran W	New York	New York	40 43	74 05	75	A	12
Roe, Sanford W	Germantown	Columbia	....	....	210	T	10
Russell, Cyrus H	Gouverneur	St. Lawrence	44 19	75 29	....	B. T. R	12
Smith, E. A., & daughters	Moriches	Suffolk	40 49	72 36	13	T. R	12
Soule, Prof. William	Cazenovia	Madison	42 55	75 46	1,260	B	12
Spooner, Stillman, M. D	Oneida	Madison	43 04	75 50	500	T. R	11
Trowbridge, David	Hector	Schuyler	42 30	77 00	850	N	10
Willis, Oliver R	White Plains	Westchester	41 05	73 40	273	T	12
Wilson, Rev. W. D., D. D	Geneva	Ontario	42 53	77 02	567	B. T. R	12
Wooster, Charles A	North Hammond	St. Lawrence	44 30	75 40	....	B. T. R	12
Yale, Walter D	Houseville	Lewis	43 40	75 32	....	T. R	12

NORTH CAROLINA.

Name of observer.	Station.	County.	North latitude.	West longitude.	Height.	Instruments.	No. of months received.
Adams, E. W	Goldsboro'	Wayne	35 20	77 51	102	T. R	12
Allison, Thomas A	Statesville	Iredell	35 30	80 30	....	T. R	12
Aston, E. J	Asheville	Buncombe	....	....	2,000	T	8
Brewer, Rev. Fisk P	Raleigh	Wake	35 47	78 48	....	T. R	12
Hicks, Wm. R., M. D	Oxford	Granville	36 23	78 14	....	T. R	8
Koon, F. J	Attaway Hill	Stanley	35 25	80 00	850	T. R	12
Mills, John H	Oxford	Granville	36 23	78 14	....	T	4
Wray, Alex	Guilford Mine	Guilford	36 00	80 00	....	N	2

OHIO.

Name of observer.	Station.	County.	North latitude.	West longitude.	Height.	Instruments.	No. of months received.
Bambach, Dr. G	Ripley	Brown	38 47	83 31	*106	A	1
Benner, Josiah F	New Lisbon	Columbiana	40 45	80 45	961	B. T. R	11
Burras, O	North Fairfield	Huron	41 08	82 40	660	T. R	10
Clarke, John	Bowling Green	Wood	41 22	83 40	700	T. R	12
Crane, George W	Bethel	Clermont	39 00	84 00	555	T. R	11
Doyle, Joseph B	Steubenville	Jefferson	40 45	80 47	....	B. T	4
Ferriss, E. J	Little Mountain	Geauga	41 38	81 16	1,160	T. R	12
Hammitt, John W	College Hill	Hamilton	39 19	84 26	800	T. R	11
Harper, George W	Cincinnati	Hamilton	39 06	84 27	*305	A	12
Haywood, Prof. John	Kingston	Ross	39 29	83 00	692	A	6
Huntington, George C	Kelley's Island	Erie	41 36	82 42	587	B. T. R	11
Hyde, Gustavus A Hyde, Mrs	Cleveland	Cuyahoga	41 30	81 38	683	B. T. R	12
Knoble, Samuel	Lafayette	Allen	....	....	....	T. R	2
McMillin, Smith B	East Fairfield	Columbiana	40 41	80 44	1,152	A	5
Marsh, Mrs. M. M	Ripley	Huron	41 00	82 30	965	B. P. T	7
Mathews, Joseph McD	Hillsborough	Highland	39 13	....	....	A	11
Newton, Rev. Alfred	Norwalk	Huron	41 13	82 43	....	T. R	11
Phillips, R. C	Cincinnati	Hamilton	39 06	84 27	588	B. T. R	12
Rodgers, Alexander P	Gallipolis	Gallia	39 00	82 00	600	T. R	4
Shreve, Charles R	Martin's Ferry	Belmont	40 10	80 49	....	T	6
Smith, C. H., M. D	Kenton	Hardin	40 10	83 54	1,562	T	12
Smurr, T. A., M. D	Cleveland	Cuyahoga	41 37	81 46	....	T	8
Thompson, Rev. David	Milnersville	Guernsey	40 10	81 45	....	T. R	11
Thompson, Prof. H. A	Westerville	Franklin	40 04	83 00	....	A	5
Trembley, J. B., M. D	Toledo	Lucas	41 39	....	604	B. T. R	12
True, H. A., M. D	Marion	Marion	40 35	83 08	1,077	T. R	11
Tuckerman, L. B	College Hill	Hamilton	39 19	84 26	800	T. R	7
Williams, Prof. M. G	Urbana	Champaign	40 06	83 43	1,015	B. T. R	11
Wilkinson, John R	Williamsport	Pickaway	39 37	83 07	....	T. R	3
Winger, Martin	Wooster	Wayne	40 49	81 57	872	T	11

* Above low water in the Ohio river.

List of meteorological stations and observers, &c.—Continued.

OREGON.

Name of observer.	Station.	County.	North latitude.	West longitude.	Height.	Instruments.	No. of months received.
			° ′	° ′	*Feet.*		
Barnard, A. D	Corvallis	Benton	44 30	123 00		T	11
Hindman, S. M. W	Albany	Linn	44 22	123 00	600	R	9

PENNSYLVANIA.

Name of observer.	Station.	County.	North latitude.	West longitude.	Height.	Instruments.	No. of months received.
Baker, William E.	Ickesburg	Perry	40 27	77 23		T. R	6
Bentley, E. T	Tioga	Tioga	42 00	77 00	1,000	T. R	11
Bruckart, H. G	Silver Spring	Lancaster	40 05	76 45		T	3
Brugger, Samuel	Fleming	Centre	40 55	77 53	780	T. R	6
Darlington, Fenelon	Pocopson	Chester	39 40	75 37	218	T. R	12
Day, Theodore	Dyberry	Wayne	41 36	75 19		T	12
Dutton, J. Russell	Stevensville	Bradford	41 45	76 35	309	T. R	2
Fenton, Elisha	Grampian Hills	Clearfield	41 00	78 40	1,400	B. T. R	12
Grathwohl, John	Blooming Grove	Pike	41 30	75 00		T. R	12
Hance, Ebenezer	Fallsington	Bucks	40 12	74 48	30	B. T. R	12
Heisely, Dr. John	Harrisburg	Dauphin	40 16	76 15		A	12
Hoffer, Dr. Jacob R.	Mount Joy	Lancaster	40 08	76 32		B. T. R	10
James, Prof. C. S	Lewisburg	Union	40 58	76 58		A	12
Kirkpatrick, Prof. Jas. A	Philadelphia	Philadelphia	39 57	75 11	60	A	12
Kohler, Edward	North Whitehall	Lehigh	40 44	75 28	450	T	12
McConnell, E. M	New Castle	Lawrence	41 00	80 12		T	12
Martindale, Isaac C	Byberry	Philadelphia	40 05	75 00	70	N	1
Mayer, Prof. Alfred M	Bethlehem	Northampton	40 38	75 23		B. P. T	6
Meehan, Thomas	Germantown	Philadelphia				T	11
Milliken, John T	North East	Erie				N	4
Raser, John Heyl	Reading	Berks	40 20	75 57	269	T	12
Smith, William, D. D	Canonsburg	Washington	40 16	80 10	850	B. T. R	12
Spencer, Miss Anna	Horsham	Montgomery	40 00	75 11	250	B. T. R	12
Spera, W. H	Ephrata	Lancaster				T. R	12
Stewart, F. L	Murrysville	Westmoreland	40 28	79 35	960	A	1
Taylor, John	Connellsville	Fayette	40 00	79 36		T	12
Taylor, Rev. R. T	Beaver	Beaver	40 43	80 23		T. R	3
Tolman, Rev. Marcus A	Franklin	Venango	41 24	79 51		T	3
Tooker, Nathan C	Bethlehem	Northampton	40 38	75 23		B. P. T	1

RHODE ISLAND.

Name of observer.	Station.	County.	North latitude.	West longitude.	Height.	Instruments.	No. of months received.
Caswell, Prof. Alexis	Providence	Providence	41 49	71 25	120	A	4
Crandall, William H	Newport	Newport	41 28	71 21	25	T. R	12

SOUTH CAROLINA.

Name of observer.	Station.	County.	North latitude.	West longitude.	Height.	Instruments.	No. of months received.
Cornish, Rev. John H	Aiken	Barnwell	33 32	81 34	565	B. T. R	12
Petty, Charles	Wilkensville	Union	34 50	81 36		N	12

TENNESSEE.

Name of observer.	Station.	County.	North latitude.	West longitude.	Height.	Instruments.	No. of months received.
Bancroft, Rev. C. F. P	Lookout Mount'n.	Hamilton	35 15	85 15	2,200	B. T	9
Doak, S. S. & W. S	Greenville	Green	36 05	82 50		T	12
French, Fred. H	Nashville	Davidson				T	2
Goldsmith, Edward	Memphis	Shelby	35 08	90 08	262	B. T. R	4
Parker, Joseph M., M. D	Franklin	Williamson	35 42	86 51		T. R	7
Stewart, Prof. Wm. M	Clarksville	Montgomery	36 29	87 13	481	A	11
Williams, Edward F	Lookout Mount'n.	Hamilton	35 15	85 15	2,200	B. T	3

TEXAS.

Name of observer.	Station.	County.	North latitude.	West longitude.	Height.	Instruments.	No. of months received.
Baxter, Miss E	Houston	Harris	29 50	95 30		T	3
Gantt, W. H., M. D	Chappell Hill	Washington	30 15	96 21	542	T. R	2
Glasco, J. M	Gilmer	Upshur	32 46	94 51	950	T	3
Merrill, Edward, M. D	Waco	McLernan	31 35	96 50		T	8
Rutherford, M	Long Point	Washington	30 16		400	T. R	3
Stevens, Hennell	Ced'r Grove Plan.	Brazoria	29 10	96 56	60	B. T. R	12
Van Nostrand, J	Austin	Travis	30 29	97 46	650	T. P. R	12

List of meteorological stations and observers, &c.—Continued.

UTAH.

Name of observer.	Station.	County.	North latitude.	West longitude.	Height.	Instruments.	No. of months received.
			° ′	° ′	*Feet.*		
Bullock, Thomas	Wanship	Summit	40 42	111 20	6,200	T	11
Lewis, James	Harrisburg	Washington				T	7
Phelps, W. W	Salt Lake	Salt Lake	40 45	111 26	4,320	T. R	7

VERMONT.

Name of observer.	Station.	County.	North latitude.	West longitude.	Height.	Instruments.	No. of months received.
Buckland, Harmon	Brandon	Rutland	43 45	73 00	460	T. R	6
Cutting, Hiram A	Lunenburg	Essex	44 28	71 41	1,124	A	12
Eaton, Benjamin F., M.D.	Barnet	Caledonia	44 18	72 05	952	B. T. R	5
Paddock, James A	Craftsbury	Orleans	44 40	72 30	1,100	T. R	4
Paine, Charles L	Randolph	Orange	43 35	72 36	700	T. R	11
Perry, Rev. John B	Wilmington	Windham	42 53	72 47	1,250	B. T	2
Sheldon, Harmon A	Middlebury	Addison	43 59	73 10	398	A	12
Wild, Edward P	North Craftsbury	Orleans	44 40	72 30	1,100	T. R	8

VIRGINIA.

Name of observer.	Station.	County.	North latitude.	West longitude.	Height.	Instruments.	No. of months received.
Adams, J. F	Hewlett's	Hanover	37 52	77 45		T	6
Clark, James T., M. D	Mount Solon	Augusta	38 17	79 03		T	7
Jones, Benjamin W	Surry C. H	Surry	37 10	76 50		T	8
Meriwether, Charles J	Near Lynchburg	Bedford	37 15	79 10		T	10
Potts, Jean G	Cape Charles	Northampton	37 08	75 53	20	T. R	9
Stalnaker, J. W	Snowville	Pulaski	37 00	80 40		T. R	4

WASHINGTON.

Name of observer.	Station.	County.	North latitude.	West longitude.	Height.	Instruments.	No. of months received.
Bulkeley, S. S	Port Townsend	Jefferson	48 07	122 44	8	T. R	4
Sampson, Alexander	Neah Bay		48 22	124 37	17	T. R	2

WEST VIRGINIA.

Name of observer.	Station.	County.	North latitude.	West longitude.	Height.	Instruments.	No. of months received.
Bliven, Robert H	Burning Springs	Wirt	38 56	81 21		T	1
McDowell, W. H	Romney	Hampshire				T	9
Roffe, Charles L	Ashland	Cabell	38 30	82 16	600	T. R	12
Sharp, D. W. H	Grafton	Taylor				T	12

WISCONSIN.

Name of observer.	Station.	County.	North latitude.	West longitude.	Height.	Instruments.	No. of months received.
Breed, E. Everett	Embarass	Waupaca	44 51	88 37		T. R	12
Curtis, W. W	Rocky Run	Columbia	43 26	89 19		T. R	12
Dungan, John L	New Lisbon	Juneau	43 45	90 00		T	8
Eddy, Levens	Delavan	Walworth	42 39	88 37	957	B. T. R	12
Foye, J. C	Appleton	Outagamie	44 10	88 35	800	A	2
Gale, William	Galesville	Trempaleau	44 06	91 16	775	B. T	5
Hicks, John	Appleton	Outagamie	44 10	88 35	800	T	3
Hurlburt, Dr. M. J. E	Appleton	Outagamie	44 10	88 35	800	A	2
Lapham, Incr'se A., LL.D.	Milwaukee	Milwaukee	43 03	87 56	604	A	12
Lups, Jacob	Manitowoc	Manitowoc	44 07	87 45	658	B. T. R	12
Mead, H. C	Waupaca	Waupaca	44 20	89 11	1,000	T	11
Moeller, G	Plymouth	Sheboygan	43 44	88 07	870	B. T	12
Porter, Henry D	Beloit	Rock	42 30	89 04	780	A	7
Shintz, Henry J	Edgerton	Rock	42 30	89 00	1,700	T	6
Tate, Andrew	Bayfield	Bayfield				T	4
Waite, M. C	Baraboo	Sauk	43 27	89 45	920	T. R	12
Webster, C. D	Waupaca	Waupaca	44 21	89 13		T. R	5
Whiting, William H	Geneva	Walworth	42 30	89 41	600	T	8
Winkler, Carl, M. D	Milwaukee	Milwaukee	43 03	87 57	630	B. T. R	12

DEATHS OF OBSERVERS.

Stephen O. Mead, Claremont, New Hampshire, March 18, 1867.
James A. Paddock, Craftsbury, Vermont, April, 1867.
Professor Chester Dewey, Rochester, New York, December 15, 1867.
M. M. Matthews, M. D., Rochester, New York, November, 1867.
Henry M. Corey, Fernandina, Florida, August 19, 1867.

Colleges and other institutions from which meteorological registers were received during the year 1867, *included in the preceding list.*

Nova Scotia	Acadia College	Wolfville.
Alabama	Greene Springs School	Havana.
Arkansas	Normal School	Helena.
California	State Insane Asylum	Stockton.
Connecticut	Wesleyan University	Middletown.
	Young Ladies' Collegiate Institute	New Haven.
Illinois	Lombard University	Galesburg.
	Northwestern University	Evanston.
Iowa	Cornell College	Mount Vernon.
	Griswold College	Davenport.
	Iowa State University	Iowa City.
Kansas	Agricultural College	Manhattan.
Maryland	St. Timothy's Hall	Catonsville.
	Mount St. Mary's College	Emmittsburg.
Massachusetts	Amherst College	Amherst.
	State Lunatic Hospital	Worcester.
	Williams' College	Williamstown.
Michigan	State Agricultural College	Lansing.
Mississippi	Fayette Female Academy	Fayette.
Missouri	St. Louis University	St. Louis.
	Grand River College	Edinburg.
New Hampshire	St. Paul's School	Concord.
New Jersey	Rutgers College	New Brunswick.
New York	Columbia College	New York.
	Institution for Deaf and Dumb	New York.
	Erasmus Hall Academy	Flatbush.
	Oneida Conference Seminary	Cazenovia.
	St. Francis Xavier College	New York.
	University of Rochester	Rochester.
Ohio	Farmers' College	College Hill.
	Otterbein University	Westerville.
	Urbana University	Urbana.
	Woodward High School	Cincinnati.
Pennsylvania	Jefferson College	Canonsburg.
	Lehigh University	Bethlehem.
	Lewisburg University	Lewisburg.
Tennessee	Stewart College	Clarksville.
	Lookout Mountain Educational Institution	Lookout Mountain.
	Tusculum College	Greenville.
Texas	Institution for Deaf and Dumb	Austin.
Wisconsin	Beloit College	Beloit.
	Galesville University	Galesville.
	Lawrence University	Appleton.

METEOROLOGICAL MATERIAL CONTRIBUTED IN ADDITION TO THE REGULAR OBSERVATIONS.

Académie Royale de Belgique.—Observations des Etoiles filantes périodiques de Novembre, 1866. (Extr. des Bulletins, 2me sér., t. xxii, No. 12, 1866.) 8vo., 24 pages.

Sur l'Heure des Chutes d'Aérolithes, par M. Ad. Quetelet, secrétaire perpétuel de l'Académie Royale de Belgique. (Extr. des Bulletins, 2me ser., t. xxiii, No. 3, 1867.) 8vo., 8 pages.

Etoiles filantes.—Publication des Annales Météorologiques de l'Observatoire Royal. Sur l'Héliographie et la Sélénographie.—Orages observés à Bruxelles et à Louvain du 7 Fevrier jusqu'à la fin de Mai. Communications de M. Ad. Quetelet, Directeur de l'Observatoire Royal de Bruxelles. (Extrait des Bulletins, 2me série, tome xxiii, Nos. 5 et 6, 1867.) 8vo., 20 pages.

Administration des Mines de Russie.—Correspondance Météorologique, publication annuelle de l'Administration des Mines de Russie, redigée par A. T. Kupffer, Directeur de l'Observatoire Physique Central de Russie et membre de l'Académie des Sciences de St. Petersbourg. Année 1864. St. Petersbourg, 1865. 4to., 102 pages.

Asiatic Society of Bengal.—Journal of the Asiatic Society of Bengal, edited by the Natural History Secretary. Calcutta, 1866; 8vo. [Contains monthly abstracts of the results of the hourly meteorological observations taken at the surveyor general's office, Calcutta.]

Ballou, Nahum E., M. D.—Summary of observations made during the year 1867, at Sandwich, De Kalb county, Illinois.

Bannister, Henry M.—Observations made at Fort St. Michael, Norton sound, Russian America, from October 1, 1865, to August 31, 1866. (The observations from December 10, 1865, to January 16, 1866, were made by Mr. J. M. Bean.)

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Wind Charts of the Ocean; 16 large charts. Instructions and blank forms for meteorological observations.

Bruhns, Prof. Dr. C.—Meteorologische Beobachtungen, angestellt auf der Leipziger Universitäts-Sternwarte in den Jahren 1864 und 1865. Herausgegeben von Prof. Dr. C. Bruhns, Director de Sternwarte. Mit zwei graphischen Darstellungen der Beobachtungen, von G. Schreiber. 8vo., 192 pages.

Resultate aus den meteorologischen Beobachtungen, angestellt an mehreren Orten im Königreich Sachsen in den Jahren 1760 bis 1865, und an den zweiundzwanzig Königl. Sächsischen Stationen im Jahre 1865, nach den monatlichen Zusammenstellungen im statistischen Bureau des königlichen Ministeriums des Innern. Bearbeitet von Dr. C. Bruhns, Director der Sternwarte und Professor der Astronomie in Leipzig. Zweiter Jahrgang. Leipzig, 1867. 4to., 147 pages.

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ing upon the great North American lakes. By I. A. Lapham, LL.D., of Milwaukee, Wisconsin."]

Cockburn, S.—Rain-fall at Belize, British Honduras, during each month from August, 1862, to April, 1868, inclusive.—Meteorological phenomena at Belize, 1863.

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Eddy, Levens.—Summary of observations for the year 1866, at Delavan, Wisconsin; printed slip.

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Ernst, A.—Meteorological data for Caracas, Venezuela, South America, communicated by G. A. Ernst, Caracas. 10 pages letter paper.

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Heimstreet, John W.—Record of the amount of rain during May, from 1826 to 1846, at Lansingburg, three miles north of Troy, New York, and during May, from 1848 to 1867, at Troy.

Heine, W.—Revue des Cours Scientifiques de la France et de l'étranger, 4 Mai, 1867. Paris, 4to. [It contains: "Les Etoiles filantes. Essai de théorie générale d'après les travaux de M. Newton, des Etats-Unis."] By M. W. de Fonvielle, Pp. 356—365.

Heineken, Dr.—See Naturwissenschaftlicher Verein.

Hyde, G. A.—Summary of observations for the year 1867, at Cleveland, Ohio. (Newspaper slip.)

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Jelinek, Dr. Carl.—Zeitschrift der österreichischen Gesellschaft für Meteorologie. Redigirt von Dr. Carl Jelinek. Verlag von Wilhelm Braumüller in Wien; 8vo. [Published on the 1st and 15th of every month.]

Über die Täglichen Änderungen der Temperatur nach den Beobachtungen der Meteorologischen Stationen in Österreich. Von Dr. K. Jelinek, wirklichem Mitgliede der Kaiserlichen Akademie der Wissenschaften. Vorgelegt in der Sitzung am 12. Juli, 1866. Wien, 1867. 4to., 40 pages.

Über die mittlere Temperatur zu Wien, nach 90-jährigen Beobachtungen, und über die Rückfälle der Kälte im Mai. Von Dr. C. Jelinek. (Vorgelegt in der Sitzung vom 2. November, 1866.) 8vo., 83 pages.

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Some observations regarding the earthquakes in Saint Thomas and the neighboring islands, commencing November 18, 1867.

Leeds Philosophical and Literary Society.—Forty-sixth report of the council of the Leeds Philosophical and Literary Society, at the close of the session 1865–'66; read at the annual meeting, May 1, 1866. [Contains an abstract of the mean temperature and height of barometer, and amount of rain, for each month during the year 1865, from the meteorological register kept at the hall of the society.]

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Maynard, Edward.—See State Department.

Meteorological Committee, Calcutta.—Report on the Calcutta cyclone of the 5th October, 1864, by Lieutenant Colonel J. E. Gastrell and Henry F. Blanford, A. R. S. M., with maps and diagrams illustrating the origin and progress of the storm and the track of the storm wave. Printed and published for the government of Bengal, by order of the lieutenant governor. Calcutta, 1866. 8 vo., 184 pages.

Meteorological Society, (British.)—Proceedings of the Meteorological Society, edited by James Glaisher, esq., F. R. S., secretary. London, 1867.

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Michigan State Agricultural College.—Fifth annual report of the secretary of the State board of agriculture of the State of Michigan, for the year 1866. It contains a copy in detail of the meteorological observations for the year 1866, taken at the State Agricultural College, by R. C. Kedzie, professor of chemistry. Also, an article on the effect of forest trees on climate.

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Prettner, J.—Klima und Witterung von Klagenfurt. Von J. Prettner. (Aus dem Jahrbuch des Nat.-hist. Museums, VII, Seite I.) Klagenfurt, 1865. 8vo., 80 pages.

Quetelet, Ernest.—Mémoire sur la temperature de l'air à Bruxelles, par Ernest Quetelet, Membre de l'Académie Royale des Sciences, des Lettres et des Beaux-Arts de Belgique. Bruxelles, 1867. 4to., 103 pages.

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Report of the Bahamas for the year 1864, by Governor Rawson. London, 1866. 8vo., 122 pages. [It contains three pages on the climate and meteorology of the islands.]

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Rosset, Professor C.—See Société Vaudoise des Sciences Naturelles.

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Monthly notices of papers and proceedings of the Royal Society of Tasmania, for 1863, 1864, 1865. 3 vols., 8vo., containing the meteorology for each month.

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Dell' Influenza della Luna sulle vicende atmosferiche. Memoria di G. V. Schiaparelli, Membro effetivo del R. Istituto Lombardo, letta alla Classe di Scienze matematiche e naturali nella tornata del 24 Maggio, 1866. Estratto dalle Memorie del R. Istituto Lombardo, vol. x. I della serie III. Milano, 1866. 4to., 26 pages.

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Schweizerische Naturforschende Gesellschaft.—Schweizerische Meteorologische Beobactungen, herausgegeben von der Meteorologischen Centralanstalt der Schweizerischen Naturforschenden Gesellschaft, unter Direktion von Professor Dr. Rudolf Wolf. Dritter Jahrgang, 1866. Zurich. 4to.

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Shepherd, Rev. J. Avery.—Irregular observations at Pass Christian, Mississippi, May to July, 1860; and at Montgomery, Alabama, September, 1860, to April, 1861.

Sisson, Rodman.—Summary of thermometer record kept at Abington, Luzerne county, Pennsylvania, during the years 1864, 1865, 1866, 1867, giving the means of each month, also range and extremes, from observations made daily at sunrise, noon, and sunset.

Smith, Haden Patrick.—Weekly abstract of observations kept at the Central Park, New York, with a full set of instruments, from July, 1867, to the end of the year.

Smith, M. D.—Amount of rain in each month from November, 1863, to November, 1867, at Meadow Valley, Plumas county, California.

Société d'Agriculture, Sciences, Arts et Belles-Letters du departement d'Indre-et-Loire.—Annales de la Société. Publiées sous la direction de M. l'Abbé C. Chevalier, secretaire-perpétuel, Rédacteur. 8vo. [Published monthly at Tours. Each number contains meteorological observations made at the botanical garden of Tours, by M. Barnsby.]

Société d'Agriculture, Sciences et Arts de la Sarthe.—Bulletin, published quarterly. [The last part for 1866 contains: "Tableau résumé des observations météorologiques faites au Mans en 1866, par M. D. Bonhomet."]

Société Imperiale des Naturalistes de Moscou.—Bulletin de la Société Impériale des Naturalistes de Moscou, publié sous la rédaction du Docteur Renard, 1866. [Contains: "Observations météorologiques, faites a l'Institut des Arpenteurs (dit Constantin) de Moscou, et communiquées par J. Weinberg."]

Société Météorologique de France.—Nouvelles Météorologiques, publiées sous les auspices de la Société Météorologique de France. Commission de rédaction, MM. Charles Sainte-Claire Deville, président de la Société; Marié Davy, secretaire de la Société; Renou, Lemoine, Sonrel. [Began January, 1868; published the 1st of each month; 8vo. 32 pages.]

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Société Vaudoise des Sciences Naturelles, Lausanne.—Bulletin, volume IX, No. 55, July, 1866. [Contains: Résumé des Années Météorologiques 1863 et 1864, pour Lausanne, par J. Marguet, professeur; pp. 139–151. Also, for the year 1865, four diagrams without text.]—Bulletin, volume IX, No. 56, December 1866. [Contains: Note sur l'Influence de la Lune sur la Terre, par J. Marguet, professeur; pp. 225–236.—Quelques observations anormales faites sur les Psychromètres à la station météorologique de Bex, par C. Rosset, professeur; pp. 243–249.]

State Department.—An account of a cyclone encountered in the Indian ocean, January 6 and 7, 1867, by the United States steamer Monocacy, while on her passage from Simon's bay, South Africa, to Mauritius. By Nicholas Pike, United States consul, Port Louis.

Observations made at Turk's Island, West Indies, in September and October, 1867, by J. C. Crisson; forwarded by Edward Maynard, United States consul.

An account of the weather in Europe during the month of March, 1867. By William W. Murphy, United States consul at Frankfort.

Tayloe, Edward T.—Table giving the amount of rain during each month from 1850 to 1866, inclusive, at Powhatan Hill, King George county, Virginia; also monthly averages for the whole period.

Rains of the year 1867, at Powhatan Hill, King George county, Virginia.

Thoms, William Faulds, M. D.—Diagram showing the effects of the meteorological influences on mortality in the city of New York, 1866.

United States Naval Observatory.—Amount of rain measured at the United States Naval Observatory, Washington, D. C., during each month from 1852 to 1867, inclusive, except the years 1861, 1862, 1863.

Universitäts-Bibliothek, Basel.—Die Erfindung des Thermometers und seine Gestaltung im XVIII. Jahrhundert. Von Dr. Fritz Burckhardt. Mit einer lithogr. Tafel. Basel, 1867. 4to., 56 pages.

Wild, D. H.—Die selbstregistrirenden meteorologischen Instrumente der Sternwarte in Bern. Von Dr. H. Wild, Professor der Physik an der Universität Bern und Director der Sternwarte daselbst. Extraabdruck aus dem II. Bande von Carl's Repertorium. Mit 9 Tafeln, (No. XXII bis XXX.) München, 1866. 8vo., 44 pages.

Willet, Joseph E.—Indian Summer, by Joseph E. Willet, professor of natural philosophy and chemistry in Mercer University, Georgia. From the American Journal of Science and Arts, November, 1867. 8vo., 8 pages.

Williams, R. G.—Record of thermometer kept at Saugerties, Ulster county,

New York, at 7 a. m., from January 14, 1863, to June 30, 1865, with daily notices of weather during the same period.

Record of thermometer and barometer at Waterbury, Connecticut, for the year 1866.

Williams, S. R.—Abstract of observations for each month of the year 1867, at Lexington, Kentucky.

Williamson, James, Director of the Kingston Observatory.—Abstracts of meteorological register, University of Queen's College, Kingston, Canada West, for 1859 and 1860, giving the means, range, and extremes of each month. On printed slips. The slip for 1860 also contains the annual means for 1856 to 1861, inclusive.

Heis, Professor Dr.—Wochenschrift für Astronomie, Meteorologie und Geographie. Neue Folge. Zehnter Jahrgang. Redigirt von Professor Dr. Heis in Münster. Druck und Verlag von H. W. Schmidt in Halle. [Year 1867; published weekly.]

Wright, J. W. A.—Summary of observations for the year 1867, at Greene Springs, Alabama.—Six articles on the climate of central Alabama and Mississippi, published in the "Alabama Beacon," containing facts and inferences deduced from the observations made at Greene Springs, and their comparison with other years and localities.

(*Unknown.*)—Newspaper slips giving daily temperature and rain at Paramaribo from June 6 to December 15, 1867, with a few omissions.

Meteorological registers received for the year 1867, *or some part of it.*

	Full sets of instruments.	Partial sets of instruments.	No instruments.
British America	2	2	....
Maine	3	9	....
New Hampshire	1	7	1
Vermont	2	6	....
Massachusetts	6	10	....
Rhode Island	1	1	....
Connecticut	2	4	....
New York	5	28	1
New Jersey	4	11	....
Pennsylvania	4	22	2
Delaware	......	1	....
Maryland	2	4	....
Virginia	......	6	....
West Virginia	......	4	....
North Carolina	......	7	1
South Carolina	......	1	1
Georgia	......	1	....
Florida	1	5	....
Alabama	......	7	....
Louisiana	......	3	....
Mississippi	......	4	....
Texas	......	7	....
Arkansas	......	......	2
Tennessee	1	5	....
Kentucky	1	2	....
Ohio	6	24	....
Michigan	1	10	2
Indiana	4	8	....

	Full sets of instruments.	Partial sets of instruments.	No instruments.
Illinois	5	23	....
Missouri	2	7	....
Wisconsin	4	15	....
Minnesota	2	7	....
Iowa	4	25	....
Kansas	......	9	....
Nebraska	......	6	....
Colorado	......	1	1
Utah	......	3	....
Montana	......	2	....
Washington	......	2	....
Oregon	......	2	....
California	3	2	....
MEXICO.			
Mirador	1	......	....
CENTRAL AMERICA.			
San José, Costa Rica	......	1	....
Aspinwall, Panama	1	......	....
WEST INDIES.			
Turk's Island	......	1	....
BERMUDA.			
St. George's	1	......	....
Total	69	305	11

REPORT OF THE EXECUTIVE COMMITTEE.

The Executive Committee respectfully submit the following report in relation to the funds of the Institution, the receipts and expenditures for the year 1867, and the estimates for the year 1868:

STATEMENT OF THE FUND.

The original amount received as the bequest of James Smithson, of England, deposited in the treasury of the United States, in accordance with the act of Congress of August 10, 1846		$515,169 00
The residuary legacy of Smithson, received in 1865, deposited in the treasury of the United States in accordance with the act of Congress of February 8, 1867		26,210 63
Total bequest of Smithson		541,379 63
Amount deposited in the treasury of the United States, as authorized by the act of Congress of February 8, 1867, and directed by the Board of Regents, derived from part of savings of income and increase of value of investments		108,620 37
Total permanent Smithson fund in the treasury of the United States		$650,000 00
In addition to the above there remains of the extra fund derived from savings of income, &c., Virginia State 6 per cent. bonds for	$53,500 00	
Also, additional Virginia bonds issued for unpaid interest to January 1, 1867	19,260 00	
Par value		$72,760 00

Present value, about $30,000.

Receipts and expenditures for 1867.

RECEIPTS.

Interest on the original bequest of Smithson, viz: 6 per cent. on $515,169	$30,910 14
Interest on the amount added to the original principal in the United States treasury, authorized by act of Congress February 8, 1867, viz: February 19, 1867, $34,831; February 27, $30,544; April 1, $68,906 25	6,420 68
Interest on United States 7-30 bonds, from February 15, 1865, to February 19, 1867, on $54,150	7,907 00
Interest on Virginia bonds, viz: 4 per cent. on $53,500, to December 31, 1867, (less brokerage)	2,033 00
Interest on Washington city bond, viz: 6 per cent. on $100 to July 1, 1867, ($4\frac{1}{2}$ years)	27 00

Sales of bonds and stocks, viz:			
$54,150 United States 7-30s	$57,468 00		
15,000 Tennessee 6s	9,586 78		
75,000 Indiana 5s	68,906 25		
500 Georgia 6s	358 71		
100 Washington 6s	100 00		
		136,419 74	
Sale of coin interest		14,255 41	
Sale of publications and old and useless material		527 74	
Total receipts in 1867			$198,500 71
Balance on hand, January, 1867			22,891 23
Total amount available in 1867			221,391 94

EXPENDITURES.

Amount added to the original bequest of Smithson, in the treasury of the United States, authorized by the act of Congress of February 8, 1867, and directed by the Regents, to increase the principal to $650,000, viz: residuary legacy of Smithson	$26,210 63		
Additional deposits	108,620 37		
		$134,831 00	
Expenses for the year 1867—			
Building and furniture	38, 650 74		
General expenses	12,488 84		
Publications and researches	10,030 25		
Library, museum, and exchanges	13,905 55		
Total expenses		75,075 38	
Total expenditure and investment during 1867			$209,906 38
Balance on hand January, 1868			11,485 56

Statement in detail of expenditures for current operations of the year 1867.

BUILDING.

Reconstruction of parts injured by fire	$35,102 35	
Repairs to old parts	2,137 91	
Furniture and fixtures	1,410 48	
		$38,650 74

GENERAL EXPENSES.

Meetings of the Board	256 50
Lighting	204 55
Heating	808 65
Postage	714 45
Stationery	$892 79
General printing	194 06
Incidentals, viz: hardware, tools, materials for cleaning, &c	241 19

Payment for loss of tools by the fire, authorized by resolution of the Board, February 1, 1867	$500 00	
Salaries secretary, clerks, and laborers	8,676 65	
		$12,488 84

PUBLICATIONS AND RESEARCHES.

Smithsonian contributions, (quarto)	$4,621 76	
Smithsonian miscellaneous collections, (octavo)	2,045 20	
Smithsonian report, illustrations, stereotyping, &c	920 18	
Meteorology	1,044 39	
Apparatus	457 82	
Laboratory	17 41	
Explorations	923 49	
		10,030 25

LIBRARY, MUSEUM, AND LITERARY EXCHANGES.

Purchase of books and binding	$719 10	
Literary and scientific exchanges	3,507 87	
Assistants in museum	5,890 39	
Incidentals for museum, alcohol, benzine, &c	1,715 81	
Freights	2,072 38	
		13,905 55
Total expenditure in 1867		75,075 38

The Board of Regents having directed the sale of the United States 7.30 bonds, as also the Indiana, Georgia, and Washington bonds, the proceeds to be applied to the increase of the permanent capital, this was accordingly done through the agency of the bankers of the Institution. The act of Congress of February 8, 1867, passed in accordance with the memorial of the Board of Regents, (see report for 1866, page 74,) authorized the Institution to deposit with the Secretary of the Treasury, on the same terms as the original bequest, the residuary legacy of Smithson, together with other sums not exceeding, with the original, $1,000,000. From part of the proceeds of the sale of the United States and State stocks referred to, the sum of $108,620 37, with the residuary legacy, $26,210 63, making $134,831, was deposited in the treasury of the United States; thus making the total amount of the Smithson fund perpetually in the United States treasury, bearing 6 per cent. interest, payable semi-annually, $650,000.

The Commissioner of Agriculture continues to pay one-half of the salary of the clerk employed to take charge of the meteorological statistics.

The appropriation annually made by Congress "for the care and preservation of the collections of the exploring and surveying expeditions of the government" has been expended, as heretofore, under the direction of the Secretary of the Interior, and as the amount was increased for the year ending July 1, 1868, from $4,000 to $10,000, a part of this has been applied to the preservation of that part of the building devoted to the collections, and other purposes.

The State of Virginia has paid four per cent. interest on its stock, reserving two per cent. in Richmond, to be paid whenever the conflicting claims between the old State and the new State of West Virginia should be settled. All the interest due on the stock of the State up to the 1st of January, 1867, amounting to $19,260, has been funded by the issue of new bonds bearing six per cent. interest, none of which has, however, yet been paid. The total amount of Vir-

ginia stock now held by the Institution is $72,760, which it is considered advisable to retain for the present.

The current income of the Institution is now deposited in the First National Bank of Washington, the payment of bills being by checks drawn by the Secretary, in accordance with the regulations prescribed by the Board at its last annual session.

The following may be considered an approximate estimate for the year 1868.

ESTIMATED RECEIPTS.

Interest on the Smithson fund in the treasury of the United States, viz: six per cent. on $650,000, payable July 1, 1868, and January 1, 1869	$39,000 00
Probable premium on coin, say at 33 per cent	13,000 00
Interest on Virginia bonds, viz.: 4 per cent. on $53,500	2,140 00
Balance on hand January 17, 1868	11,485 56
	65,625 56

APPROPRIATIONS.

For current operations of the Institution	$34,000 00
For building, (including outstanding debts,)	20,000 00
Estimated balance January 1, 1869	11,625 56
	65,625 56

In conclusion, the committee have the satisfaction of again calling attention to the fact that all the expenditures from the organization of the establishment to the present time, including $450,000 on the building, the publication and distribution of 200,000 quarto and octavo volumes; the collection of a library of 60,000 works; a museum containing 1,000,000 specimens; and the distribution to other institutions of 250,000 specimens, have been made exclusively from the income and its investments, and that the bequest has been increased by an addition this year of $108,620 37, making the total capital invested in United States and other securities $722,760.

Attention is called to the expense of the National Museum, consisting of the collections of various government exploring expeditions. In addition to the appropriation by Congress for this object, from the income of the Institution the sum of $7,606 20 has been expended during 1867.

The committee have examined 680 vouchers, embracing several thousand items, for payments during the year for legitimate purposes of the Institution, and find them correct and conformed to the rules adopted by the Regents on the 22d of February, 1867.

RICHARD DELAFIELD.
RICHARD WALLACH.
PETER PARKER.

WASHINGTON, *April* 14, 1868.

REPORT OF THE BUILDING COMMITTEE FOR 1867.

It was stated in the report presented to the Board at its last session that it was proposed, during the year 1867, to roof the main building and towers and finish the interior of all the rooms, halls, staircases and main entrance, leaving the large room of the upper story, over the museum, unfinished until funds could be provided for the purpose and its future use be determined.

In accordance with this proposition the iron work of the roof over the museum was erected early in the spring, and covered with slate, fastened to the iron purlines with wire, and plastered inside with wall plaster. The iron gutters, as well as the roof, were found perfectly secure from leakage during the hardest summer rains. The severe test of ice and snow during the present winter has shown the necessity for additions in the arrangements for conducting the water from the roof. Plans for this purpose are now under discussion with the architect for persevering in the original plan, or adopting some additional security that the late severe season has indicated to be advisable.

The adaptation of new to old work, in restoring the building from the destructive effects of the fire, by substituting incombustible materials for wooden partitions, floors and roofs, has been attended, as was foreseen, with much labor and expense, as well as making additional means indispensable for rendering the roof-surfaces, valleys, and gutters water-tight in winter, when covered with snow, and occasionally ice, as well as the summer rains. Like the public buildings generally in this city, (and we may say elsewhere,) where battlements extend above the eaves with gutters behind them upon the roof, or resting upon the walls, much inconvenience, and at times damage, arises from leaks, the result of such a system. It is experienced in the Smithsonian building in consequence of the stone battlements capping all its exterior walls. The present architect's original design, approved by the committee, is set forth in his report of the operations of the year, annexed hereto. Neither time nor the funds of the Institution would permit his carrying this part of his plan into operation; and until it is done, together with some additions that the late inclement season has pointed out as advisable and necessary, the building is not secure, nor the property within it, from dampness and moisture.

The introduction of the proposed warming apparatus for all the apartments is the next most essential particular to be undertaken, to be commenced whenever the funds of the Institution will justify.

The security of the several apartments and contents are in a great measure dependent upon such an apparatus as a substitute for the stoves temporarily in use, and for which no permanent smoke-flues or other arrangements were provided.

All the rooms in the north tower, forming three suites of three in each, with two rooms on the entrance floor, one for the janitor and the other for a reception room for visitors, have been completed and are now used and occupied as offices for conducting the operations of the Institution. The several apartments in this north tower, above these offices, have also been completed. The rooms and apartments in the south tower have also been finished and are now occupied. The lower one, or that on the first floor, forms a part of the general museum and is now devoted to the reception of the larger and most weighty

articles of ethnology, such as the stone images from Central America and the stone sarcophagus from Syria.

The apartments on the next story have been fitted up with shelves, bins, and other fixtures for the transaction of the business of the literary and scientific exchanges, packing and distributing the same.

The apartments next above have been finished for the meetings and convenience of the Board of Regents; and those on the three remaining floors have also been finished and appropriated to storage and such other purposes as may become necessary. In this tower are also provided an elevator, with convenient mechanical power for removing books, specimens, etc., to and from the basement and four stories above it; water-closets and other necessary conveniences, with arrangements for the use of the Potomac water for general purposes and in large quantities in case of fire.

To increase the accommodation, two additional floors have been added to the original subdivision of the stories of the north and south towers. To furnish light to the new rooms in the south tower, circular windows have been opened through the walls, without interfering with the original architectural effect of the exterior, thus furnishing sufficient light for the purpose for which these apartments are intended.

The result of the year's labor has been to provide ample space and convenient accommodation to subserve all the wants of the Secretary of the Institution, to enable him to carry the views of Smithson into effect for the present and several years to come.

The floor-surface in 57 apartments of the building, not including the Secretary's quarters, is 66,252 square feet, or one and fifty-two hundredths of an acre, a space, so far as now can be foreseen, abundantly sufficient for the wants of the Institution, only requiring to be adapted therefor, from time to time, in details, furniture and special finish.

The following is a detailed statement of the expenditures on the building during the year 1867:

FOR RECONSTRUCTION OF PARTS DESTROYED BY THE FIRE.

Iron-work, beams, doors, &c	$2,791 67
Iron-work, new roof	8,591 50
Stone-cutting and setting	3,354 05
Brick	116 87
Bricklaying	4,277 53
Lumber	1,000 00
Carpentry	7,398 50
Elevator	450 00
Laborers	844 00
Sand	31 82
Blacksmiths	7 50
Hardware	174 90
Rope	8 25
Painting	1,927 00
Frescoing	730 00
Tin and metal work	3,135 26
Slating new roof	3,534 89
Plumbing	1,000 00
Gas-fitting	296 55
Plastering	$2,000 00
Architect	2,315 75
	43,986 04

In addition to this sum the following expenditures were made on the parts of the building not injured by the fire, or for general repairs:

Carpenters	$960 00	
Plumbers and gas-fitters	132 95	
Paints, oil, glass, and glazing	510 68	
Lumber	335 73	
Miscellaneous	198 55	
		2,137 91
Whole expenditure on building in 1867		46,123 95

Of this expenditure, $8,883 69 were paid out of the appropriation by Congress for the preservation of the government collections.

RICHARD DELAFIELD,
RICHARD WALLACH,
Building Committee.

WASHINGTON, *April* 14, 1868.

REPORT OF THE ARCHITECT.

WASHINGTON, *January* 6, 1868.

SIRS: I have the honor to report the progress made in the reconstruction of the buildings during the calendar year 1867.

The absolutely fire-proof roof of the main building, consisting of a slate covering, plastered inside and fastened by wire to a well-braced wrought-iron frame, has been firmly put in place. Many difficulties had to be overcome, since the outlines of the building, more especially the shape of gable walls and topping out of side walls, on which that most important feature of the mediæval roof, the system of guttering, depends, were prearranged upon the more pliable plan of a combustible frame and wooden sheathings. However, no pains were spared to accommodate the new conditions to the original architecture of the building. The different hips and valleys were made secure and water-tight by wide strips of sheet-copper and sheet-lead laid upon a solid foundation of sheet-iron of proper width, fastened by wire to the rafters. The gutters consist of wrought-iron, rolled into proper shape, and of a section vouched for by the Phœnix Iron Company. The connections of the sections of gutters, lengthwise, have been made so as to allow for expansion, and the connections of the gutters, sidewise, with the slate roof are effected by galvanized sheet-iron plates riveted to vertical flanges on the inner side of the gutter, and bent so as to follow up the pitch of the roof, sustained by the lowest courses of iron purlines for the slating. The mode adopted has effectively carried off the water of the heaviest rain storms of the summer, but, being of a novel design, has not fully stood the test of an extraordinary snow-storm followed by a rainfall which was freezing as fast as it came down. This action of the elements caused a thorough freezing up of the northern gutters encased inside the battlements of the side wall, and with the consequent effect of the sun upon the upper part of the roof, the melted snow in its downward course forced its way underneath the frozen face and, for want of an outlet, backed up underneath the galvanized sheet-iron described above. Plans have been laid before the building committee with a view to remedy this defect as developed by severe tests.

The ridge of the roof, another important feature, has been effectively secured by a layer of sheet-lead, capped by rolled iron, shaped to the angle formed by the ridge of roof and batted down to the roof frame.

In connection with the frame of the roof, for considerations of solidity as well as of economy, all the necessary and somewhat complicated iron stays, links and purlines have been inserted, forming the outlines of an appropriate and well-shaped ceiling in keeping with the features of a fire-proof hall, 200 feet in length by 50 feet in width. Whilst the details of this ceiling are left an open question for the decision of the committee, its main features consist of a boldly coved and bracketed cornice, surmounted by broad panelled friezes, the inner members of which are formed so as to subdivide the whole ceiling into three panels, each extending through the whole width of the building and worked out again into more minute details.

After the roof was well secured, the tracery of the double windows in the side walls was carefully taken out, the numerous weakened parts of the cut stone work supplied by new material and workmanship, and the whole work reset,

anchored and leaded, in the most substantial manner. Immediately following this work the frames and sash of these windows were made and inserted, strictly in keeping with the general style of the building.

The ceiling of the museum in lower story being now beyond accident, it was repaired, and received, with the side walls and intermediate archings, a plain frescoing. The towers and buildings, north and south of the main building, were being roofed in at the close of last year's report. In the early part of the season the brick arches for the fire-proof floors were turned, concreted, and the floors laid. During the summer they have all been finished ready for occupancy. The carriageway leading to the northern main entrance has been paved, mainly with flagging on hand, the unsightly ceiling repaired and appropriately decorated, the roof has been put in order and the unstable battlements securely fastened.

The northern main entrance door leads to the vestibule, which has an ornamental tiled floor of alternate colors; is finished octagonally, four sides being occupied by niches designed for receiving statuary; it has a marble case, and is finished in oak and frescoed in complementary colors.

The vestibule is flanked to the east by the janitor's room, which is floored with German tile, and to the west by the reception room, which is finished in imitation of walnut and has a floor of encaustic tiles. The three stories above the vestibule and adjoining rooms are fitted up for tiers of three communicating offices, each tier forming a compartment, secured by fire-proof iron doors, consisting of two layers of sheet-iron, with intermediate frame and air-space. Wooden flooring on top of the fire-proof arches has been preferred for office purposes. The higher stories of the towers form rooms of a miscellaneous character, are approached by iron stairs and floored with pressed bricks on the concrete. The main stairs and stairway have been finished with tiled floors and landings, plastered and frescoed.

South of the main building a hoist has been introduced, extending from the basement up to the fourth story. Private stairs cut to shape from old stone on hand reach up to the same height, and iron stairs, similar to those in north towers, lead up to the higher stories. The first story contains vestibule and general accommodations. The second story contains a properly fitted-up packing room and bath room. The third story contains the regents' room. The fourth, fifth and sixth stories are finished for storerooms and miscellaneous purposes.

All modern and useful improvements have been introduced in the restored and newly fitted rooms. In the introduction of Potomac water provisions have been made for fireplugs of sufficient size in the different stories, north and south of the main building, and the water can be shut off from any one section without incommoding the rest of the buildings. The same provision is made for the gaslight arrangements. Speaking tubes lead in all directions, tending to facilitate the transaction of business.

No funds being at disposal to introduce a contemplated modern and improved heating apparatus for the whole of the buildings, one of the functions of which would have been to perfect the satisfactory working of the new gutters by means of exhaust pipes at and around the inlets to the down-spouts, stoves were set in the fall of the year which will heat the offices and other newly created rooms for any length of time that may be found necessary.

The roof and gutters of the east wing were found to be totally out of repair and so arranged as to be difficult of remodelling. The slate roof had to be taken up and relaid, the gutters were overhauled, renewed and soldered. Other necessary repairs and alterations of a minor nature, demanded by the exigency of the case, were attended to.

The areas of casemate doors and windows around the main buildings were all out of repair. Their cappings were broken and laid so low that the surface water of the surrounding grounds backed into the basement. They were put in order

and sufficiently heightened. Brick pavements were laid in different parts of the basement of the main building.

The work has been faithfully done by the following mechanics and artisans: Brick work, Wise & Callahan; stone work, N. Acker; carpenter's work, Bird & Baker; iron work, Phœnix Iron Company and Gray & Noyes; tin and copper work, W. H. Harrover, H. Richey; plumbing, Thos. Evans; gas-fitting, A. E. Ridgway; plastering, Fenwick & Stewart; painting and glazing, M. T. Parker & MacNichol; frescoing, E. Carstens.

I have the honor to be, sirs, your most obedient servant,

ADOLPH CLUSS,
Superintending Architect.

JOURNAL OF PROCEEDINGS

OF

THE BOARD OF REGENTS.

WASHINGTON, *January* 15, 1868.

In accordance with a resolution of the Board of Regents of the Smithsonian Institution, fixing the time of beginning of the annual session on the third Wednesday of January in each year, a meeting was called for this day. Present, Hon. J. V. L. Pruyn, General Richard Delafield, Professor L. Agassiz, Hon. Peter Parker, and Professor Henry, the Secretary.

The Secretary presented the following joint resolution of the Senate and House of Representatives of the United States:

[PUBLIC RESOLUTION No. 5.]

A RESOLUTION for the appointment of Regents of the Smithsonian Institution.

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That the vacancies in the Board of Regents of the Smithsonian Institution of the class "other than members of Congress" be filled by the appointment of Theodore D. Woolsey, of Connecticut, William B. Astor, of New York, John Maclean, of New Jersey, and Peter Parker, of the city of Washington.

Approved, January 11, 1868.

The Secretary stated that on the 7th of January the Speaker of the House of Representatives had appointed the following Regents: Hon. J. A. Garfield of Ohio, Hon. L. P. Poland of Vermont, and Hon. J. V. L. Pruyn of New York.

No quorum being present, the Board, after examining the building and collections, adjourned to meet on Wednesday evening, January 22, 1868, at 7½ o'clock.

WASHINGTON, *January* 22, 1868.

A meeting of the Board of Regents was held at 7½ o'clock p. m. in the Regents' room of the Smithsonian Institution. Present, Hon. B. F. Wade, Hon. R. Wallach, Hon. L. Trumbull, Hon. G. Davis, Hon. J. A. Garfield, Hon. L. P. Poland, Hon. J. V. L. Pruyn, Prof. L. Agassiz, Rev. Dr. John Maclean, General Richard Delafield, Hon. Peter Parker, and Professor Henry, the Secretary.

Mr. Wade was called to the chair. The minutes of the last meeting were read and approved.

The Secretary stated that a vacancy existed in the Executive Committee, on account of the death of Professor Bache.

On motion it was

Resolved, That Hon. Peter Parker be elected to fill the vacancy in the Executive Committee.

The Secretary made a statement relative to the finances of the Institution, the sale of the State stocks, etc.

Gen. Delafield, on the part of the Executive Committee, presented the annual account of receipts and expenditures for 1867, and stated that a detailed report would be submitted at a future meeting.

The Secretary presented a statement in regard to international exchanges of literary, scientific and government publications. The act of Congress, passed at the last session, directing that 50 copies of every government publication should be given to the Smithsonian Institution to be exchanged for the publications of foreign governments, had not been carried out, as the public printer did not consider that the act referred to authorized the printing of extra copies of the works, and all the regular edition was already disposed of according to existing laws. Further legislation was therefore required.

Mr. Pruyn stated that the subject had been referred to the Library Committee of Congress, of which he was a member, and that he would do all in his power to promote the object desired.

Professor Agassiz, from the committee appointed at the meeting of February 1, 1867, presented a report, which, on motion of Mr. Wallach, was accepted.

After remarks by several Regents, on motion of Mr. Poland, the report was laid on the table and made the special order for the next meeting.

On motion of General Garfield the report was ordered to be printed.

The Board then adjourned to meet on Monday evening, January 27, 1868.

WASHINGTON, *January* 27, 1868.

A meeting of the Board of Regents of the Smithsonian Institution was held at 7½ o'clock p. m., in the Regents' room. Present, Chief Justice Chase, (the Chancellor,) Hon. B. F. Wade, Hon. Richard Wallach, Hon. J. A. Garfield, Hon. L. P. Poland, Hon. J. V. L. Pruyn, Professor Agassiz, Hon. Peter Parker, and Professor Henry, the Secretary.

The Chancellor took the chair, and the minutes of the last meeting were read and approved.

The Secretary presented the report for the year 1867.

Professor Agassiz presented a printed and revised copy of the report of the special committee on the use of the new room, made at the last meeting, which was read as follows:

Report of the committee appointed to consider what will be the best use for the large room in the second story of the main building of the Smithsonian Institution.

The influence the Smithsonian Institution has exercised from its origin upon the progress of science in the United States has been so marked and so deep, that in considering any step connected with the organization of the Institution, it is of the utmost importance to keep in view its bearing upon the advancement of knowledge generally. To those not familiar with the active operations of the Institution, the growing recognition of the difference between the increase and diffusion of knowledge, and the consequent establishment by Congress of a National Academy, mainly organized for the purpose of enlarging the boundaries

of science among us, are in themselves sufficient evidence of its beneficent power. The large and unique library lately transferred from the Institution to the library of Congress, and the extended intercourse between the Institution and all the learned bodies scattered over the globe, bear equally impressive testimony to the wide-spread action of the Institution.

In attempting to determine the most appropriate use to which the large building of the Smithsonian, and especially the large unappropriated hall in the second story, may be put, your committee has been led to consider the probable course the Institution may follow whenever its resources become consolidated and its means, gradually freed from their temporary application to subordinate purposes, are exclusively devoted to the special object pointed out in the will of Smithson, viz: "the increase and diffusion of knowledge among men." The policy which has led to the transfer of the Smithsonian library to that of Congress suggests the propriety of severing also the museum from the Smithsonian Institution, inasmuch as a museum is no more contemplated by the will of Smithson than a library. The accumulation of books and specimens has been a natural consequence of the organization of an institution exclusively devoted to the fostering of intellectual pursuits. But in proportion as their number increased they claimed a larger and larger part of the attention and means of the Institution until it became a matter of serious consideration how far the possession of such objects should be embraced in its general plan and scope.

As far as the library is concerned the question has been settled. It has become evident that, in consequence of the judicious distributing of its published contributions and miscellaneous works, the Smithsonian has acquired the most complete collection of learned transactions in existence; so extensive, indeed, that its preservation and natural extension would have encroached upon the specified obligations of the Institution. The disposition made of it leaves the students of science in the fullest enjoyment of this invaluable store of information, while it relieves the Smithsonian of a serious burden. Now your committee is satisfied that the museum of natural history, and the other collections preserved in the Smithsonian, stand in precisely the same relation to the Institution as the library did, and that it may be equally desirable to give them up, and with them the largest part if not the whole of the building, could this be done without injury to the collections and to the cause of natural history. However, it does not appear advisable to adopt such a course immediately; but it seems wise to keep it in view as a probability, doing meanwhile whatever is most likely to contribute to the advancement of science.

A few facts concerning the operations of the Institution should be borne in mind in this connection. In the same manner as the Smithsonian has distributed its various publications broadcast among learned institutions and individual scientific men, and obtained in return the magnificent library above alluded to, it has also distributed an immense number of specimens, and fostered in this way scientific research both at home and abroad. But for these latter contributions scattered over the whole civilized world it has neither claimed nor received adequate returns. All the duplicates of these treasures obtained at home from the various government exploring expeditions and surveys have been given away with

the understanding that the time may come when the progress of science among us would make it desirable that returns in kind should be expected.

The Smithsonian Institution has now been in operation for twenty years. In acknowledgment of its published Contributions to Knowledge it has received the splendid library which now adorns the Congressional library. Is it not time that the rights accrued in consequence of the distribution of specimens by the Institution should be called in; that this great outstanding debt, as it may well be called, should be collected before the recipients of these manifold gifts have passed away, and the benefits thus conferred by the Smithsonian are altogether forgotten; when the Institution might find it difficult to obtain, without new offerings, that which at this moment it may claim as its due?

Should this Board approve the recommendation of this committee, no time ought to be lost in giving notice to all the various institutions with which the Smithsonian is in regular correspondence, that this is henceforth to be the regular policy of the Institution. On the other hand it is indispensable that we should make the necessary preparations for receiving these objects, and also determine beforehand the ultimate destination of the extensive collections which no doubt will flow in as soon as we are prepared to take care of them. Your committee is of opinion that the great hall in the second story of the building should be used for the reception of these collections, and the smaller rooms in the towers, as far as not needed for other purposes, as laboratories to identify, arrange, classify, and distribute these collections for the greatest advantage of science among us, until suitable arrangements can be made for the organization of a great national museum, to which the whole should in the end be transferred.

It is self-evident that the collections likely to come in will soon outgrow the capacity of the Smithsonian Institution and its ability to take care of them, without applying its income to objects for which it was not intended. But the difficulty of disposing of these scientific treasures is no sufficient ground why the Smithsonian should surrender its large claims on other scientific institutions; for, in so doing, it would simply deprive the country of scientific objects, which other museums would be glad to receive should the Smithsonian be obliged to give them up before the country demands and organizes a great national museum in Washington.

To sum up these remarks, your committee recommends—

1st. That the distribution of specimens carried on by the Smithsonian Institution be continued and extended, but that at the same time proper returns be required whenever the specimens are not given out in aid of original researches or for educational purposes.

2d. That the expenses for such operations be limited to the resources especially appropriated for the purpose, and not allowed to encroach upon the regular active operations of the Institution.

3d. That the great hall of the second story of the building, and such other rooms as are not required for the regular operations of the institution, be devoted to the preservation of the scientific collections.

All of which is respectfully submitted in behalf of the committee.

L. AGASSIZ.

On motion of Mr. Garfield, after remarks by Messrs. Pruyn, Agassiz, Chase, Wade, Parker, Wallach, Garfield, and the Secretary, the recommendations of the committee, after modification, were adopted unanimously, as follows:

1st. That the distribution of specimens carried on by the Smithsonian Institution be continued and extended, but that at the same time proper returns for the past as well as for the future be required, whenever the specimens are not given out in aid of original researches or for educational purposes.

2d. That the expenses for such operations be limited to the resources specially appropriated by Congress for the purpose, and not allowed to encroach upon the regular active operations of the Institution.

3d. That the great hall of the second story of the building, and such other rooms as are not required for the regular operations of the Institution, be devoted to the preservation of the scientific collections.

On motion of Mr. Garfield, the following resolution was adopted:

Resolved, That a committee be appointed to report to the Regents, at their next meeting, what amount of appropriation should be asked of Congress for the care of the museum and for fitting up the great hall for the safe-keeping and exhibition of specimens.

Messrs. Wade, Garfield, Pruyn, Poland, and the Secretary were appointed as the committee.

The Board adjourned to meet at the call of the Secretary.

WEDNESDAY, *April* 15, 1868.

Present, Chief Justice Chase, (the Chancellor,) Hon. R. Wallach, General R. Delafield, Hon. Peter Parker, and Professor Henry, the Secretary.

No quorum being present the Board adjourned to meet on the 22d instant at 7 p. m.

WEDNESDAY, *April* 22, 1868.

A meeting of the Board of Regents was held this day in the Regents' room, at 7 o'clock p. m. Present, Chief Justice Chase, (the Chancellor,) Hon. B. F. Wade, Hon. Lyman Trumbull, Hon. Garret Davis, Hon. J. A. Garfield, Hon. J. V. L. Pruyn, General R. Delafield, Hon. Peter Parker, and Professor Henry, the Secretary.

The Chancellor took the chair, and the minutes of the last meeting were read and approved.

General Delafield presented the report of the Executive Committee for the year 1867, which was read and approved.

General Delafield presented the report of the Building Committee for the year 1867, which was read and approved.

The Secretary made a statement relative to the facilities afforded by various steamship and railroad companies in conveying the packages of the Institution free of freight.

On motion of Mr. Trumbull, the following resolutions were adopted:

Whereas the Pacific Mail Steamship Company, North German Lloyd, Hamburg American Steamship Company, General Trans-Atlantic Steamship Company, Inman line of steamers, Cunard line of steamers, Pacific Steam Naviga-

tion Company, Panama Railroad Company, and California and Mexico Steamship Company have generously aided in advancing the objects of the Smithsonian Institution and the promotion of science by the facilities they have afforded in the transportation of books, specimens, etc., free of charge: Therefore,

Resolved, That the thanks of the Board of Regents of the Smithsonian Institution are hereby given to the directors and officers of the above-named companies for this liberal and enlightened action.

Resolved, That a copy of these resolutions be transmitted by the Secretary to each of the companies.

Professor Henry submitted a statement as to the proposed researches and publications during the present year.

Hon. Mr. Parker stated that the city councils had under consideration the ceding of the canal, which bounds the Smithsonian grounds to the north, to a private company, and as this might affect the interests of the Institution he thought some action should be taken in regard to it.

On motion of General Garfield, it was

Resolved, That the Executive Committee be instructed to ascertain what measures are proposed to be taken by the city authorities of Washington in regard to the canal, so far as concerns the Smithsonian Institution.

The Chancellor called attention to the fact that a committee was appointed at the last meeting to prepare estimates for the completion of the large hall and for obtaining an adequate appropriation from Congress for the care of the government collections, and expressed the desire that this committee should act immediately in regard to the matter.

The Secretary, on behalf of the committee, stated that on consultation with the architect it was thought that $50,000 would be required for finishing the large room and supplying it with cases, and that at least $10,000 annually ought to be appropriated for the care of the museum. Whereupon it was

Resolved, That a memorial be presented to Congress asking appropriations in accordance with the report of the committee.

The Secretary gave an account of the establishment of a scientific society in Egypt publishing valuable transactions which had been received by the Institution.

The Board then adjourned to meet on Friday, May 1, at 7 o'clock p. m.

FRIDAY, *May* 1, 1868.

A meeting of the Board of Regents was held this day at 7 o'clock p. m. Present, Chief Justice Chase, (the Chancellor,) Hon. B. F. Wade, Hon. Lyman Trumbull, Hon. L. P. Poland, Hon. J. V. L. Pruyn, Hon. Richard Wallach, General R. Delafield, Hon. Peter Parker, Rev. Dr. John Maclean, and Professor Henry, the Secretary.

The Chancellor took the chair, and the minutes of the last meeting were read and approved.

General Delafield, from the Executive Committee, reported that he had collected a large amount of information in relation to the canal, (bounding the Smithsonian grounds,) but was not yet ready to make a report.

The Secretary read a copy of the memorial which had been prepared in accordance with the directions of the Board, signed by the Chancellor and Secretary, and presented to Congress,* as follows:

To the honorable the Senate and House of Representatives in Congress assembled:

In behalf of the Board of Regents of the Smithsonian Institution, the undersigned beg leave respectfully to submit to your honorable body the following statement, and to solicit such action in regard to it as may be deemed just and proper:

The act of Congress organizing the Institution ordered the erection of a building which should accommodate, on a liberal scale, besides a library and a gallery of art, a museum, consisting of all the specimens of natural history, geology, and art, which then belonged to the government, or which might thereafter come into its possession by exchange or otherwise. Although the majority of the Regents did not consider the maintenance of these objects to be in accordance with the intention of Smithson, as inferred from a strict interpretation of the terms of his will, yet in obedience to the commands of Congress they proceeded to erect a building of the necessary dimensions, and to take charge of the government collections.

The erection and maintenance of so large and expensive an edifice, involving an outlay of $450,000, and the charge of the government museum, have proved a grievous burden on the Institution, increasing from year to year, which, had not its effects been counteracted by a judicious management of the funds, would have paralyzed the legitimate operations of the establishment, and frustrated the evident intention of Smithson.

It is true that Congress, at the time the specimens were transferred to the Institution, granted an appropriation of $4,000 for their care and preservation, that being the equivalent of the estimated cost of the maintenance of these collections in the Patent Office, where they had previously been exhibited. But this sum, from the rise in prices and the expansion of the museum by the specimens obtained from about fifty exploring expeditions ordered by Congress, scarcely more than defrays, at the present time, one-third of the annual expense. In this estimate no account is taken of the rent of the part of the building devoted to the museum of the government, which, at a moderate estimate, would be $20,000 per annum.

Besides the large expenditure which has already been made on the building, at least $50,000 more will be required to finish the large hall in the second story, necessary for the full display of the specimens of the government. But the Regents do not think it judicious further to embarrass the active operations for several years to come, by devoting a large part of the income to this object, and have, therefore, concluded to allow this room to remain unfinished until other means are provided for completing it.

It is not by its castellated building nor the exhibition of the museum of the government that the Institution has achieved its present reputation, nor by the collection and display of material objects of any kind that it has vindicated the intelligence and good faith of the government in the administration of the trust; it is by its explorations, its researches, its publications, its distribution of specimens and its exchanges, constituting it an active, living organization, that it has rendered itself favorably known in every part of the civilized world, has made contributions to almost every branch of science, and brought more than ever before into intimate and friendly relations the Old and the New Worlds.

A central museum for a complete representation of the natural products of America, with such foreign specimens as may be required for comparison and generalization, is of great importance, particularly as a means of developing

* May 1.—In the House of Representatives.—Referred to the Committee on Appropriations and ordered to be printed.

and illustrating our industrial resources, as well as of facilitating the study of the relations of our geology, mineralogy, flora and fauna, to those of the Old World. But the benefit of such an establishment is principally confined to this country, and does not partake of the cosmopolitan character of an institution such as Smithson intended to found, and therefore ought not to be supported from his bequest.

The Board of Regents are confident that upon a full consideration of the case, your honorable body will grant an adequate support for the collections of the government, and also an appropriation for finishing the repairs of the building, and eventually, when the financial condition of the country will permit, for the independent maintenance of a national museum.

It may not be improper, in addition to what has been said, to recall the fact that the Smithsonian Institution has transferred, without cost, to the library of Congress, one of the most valuable and complete collections of the transactions of scientific and learned societies and serial publications in existence, consisting of at least 50,000 works, which, with the annual continuations of the same series, must render Washington a centre of scientific knowledge, and the library itself worthy of the nation; and that it has also presented to the government its valuable collection of specimens of art, illustrating the history of engraving from the earliest periods. It is prepared to render a similar service to a national museum, by the exchanges from foreign museums to which it has been a liberal contributor, and which may be obtained as soon as means are provided for their transportation and accommodation.

It may also be mentioned that the Institution has rendered important service to the government through the scientific investigations it has made in connection with the operations of the different departments, and it is not too much to say that, through the labors of its officers, it has been the means of saving millions of dollars to the national treasury.

In conclusion, your memorialists beg leave to represent, on behalf of the Board of Regents, that the usual annual appropriation of $4,000 is wholly inadequate to the cost of preparing, preserving, and exhibiting the specimens, the actual expenditure for that purpose in 1867 having been over $12,000; and they take the liberty of respectfully urging on your honorable body the expediency of increasing it to $10,000, and that a further sum of $25,000 be appropriated at this session of Congress towards the completion of the hall required for the government collections.

And your memorialists will ever pray, &c.

S. P. CHASE,
Chancellor Smithsonian Institution.
JOSEPH HENRY,
Secretary Smithsonian Institution.

On motion, the action of the Chancellor and Secretary in relation to the memorial was approved.

The Secretary gave an account of the correspondence of the Institution, and as an illustration of its diversified character read the letters which had been received that day.

On motion of Mr. Maclean, the annual report of the Secretary was accepted, and the officers of the Institution authorized to transmit it to Congress.

A motion of Mr. Wallach, in behalf of the Executive Committee, to increase the salary of the Secretary, was referred back to the same Committee, with instructions to make a report on the whole subject of the compensation of the officers of the Institution at the next meeting.

Adjourned, to meet at the call of the Secretary.

EXTRACTS FROM THE GENERAL CORRESPONDENCE SUBMITTED TO THE BOARD OF REGENTS.

From the Records of the American Academy of Arts and Sciences.

BOSTON, MASSACHUSETTS, *May* 29, 1866.

Remarks were made by the president and by the librarian on the aid rendered by the Smithsonian Institution in effecting the exchanges of the academy; and, on motion of the librarian, it was voted: That the thanks of the academy be presented to the Smithsonian Institution for the generous and efficient aid which it has rendered through its system of foreign exchanges and distribution of publications, by which the academy has greatly profited.

CHAUNCEY WRIGHT,
Recording Secretary American Academy.

From George H. Knight.

CINCINNATI, OHIO, *July* 10, 1866.

The system of weights and measures being on the tapis, ought we not to save posterity a world of trouble by once for all dethroning *ten* as the metrical number in favor of *eight*—a number susceptible of indefinite bisection, itself a cube, (2^3,) and whose square is a cube, (4^3?)

Two with its multiples is the natural division in measures; witness the old dry measure: 2 gills=one jack; 2 jacks=one pint; 2 pints=one quart; 2 quarts=one pottle; 2 pottles=one gallon; 2 gallons=one peck; 4 pecks=one bushel; 8 bushels=one-quarter; 4 quarters=one chaldron, &c.

The system would, of course, abolish the two digits, 8 and 9. Eight would be represented by the sign 10, and nine by 11, while $8. \times 8. = 100$. I am not unaware of the prodigious labor involved in such a change—a labor too great for an age which expends more on litigation than on its wheat crop; but I nevertheless believe it will be undertaken by some future age at a far greater sacrifice.

From E. C. Bolles, Secretary of the Portland Society of Natural History.

PORTLAND, MAINE, *August* 24, 1866.

The Portland Society of Natural History has always felt that the Smithsonian Institution was its best friend. Unnumbered instances of a generous regard, rising to munificence in the time of our loss and trial; wise counsels never out of place; wonderful facilities for scientific interchange most cheerfully granted, all compel us to this belief; and it is in obedience to this conviction that we lay before you, at the earliest possible moment, a statement of the present condition of our society, which, in the terrible calamity well known throughout our land, has been almost the greatest sufferer of all.

The destructive fire of July 4th consumed our building and collections, leaving, from the peculiar construction of the former, scarcely a vestige of the interior of the hall. We regret to say that this loss was entirely unnecessary. The structure was eminently fire-proof, separated by 20 feet on each side from the buildings on the right and left. A large wooden house on the right had been entirely burned without danger to our property; the library had been quietly and

safely removed; in the event of possible danger there seemed time enough to secure the cabinets, which were already so arranged as to be readily carried out, when an ill-judged explosion of powder in the building on the left blew out the few windows in our premises, and drove the burning mass of splinters and boards quite over the lower floor of our lecture-room, and left this, of course, in a moment, only a sheet of flame. This unexpected blow, almost destroying several members of the society, rendered all further efforts to save our property vain.

You will be pleased to learn that all our books and pamphlets, including our own and the Smithsonian publications, were saved. I wish that I could say as much for the collections, but, excepting about 100 species of shells, withdrawn for a special purpose and not then returned, all was lost.

And now we beg to assure you that the society *still lives*. Not even this second trial by fire shall destroy our existence and work. Although since that night of disasters every one's heart and brain have been overtaxed, we have not lost a single meeting. One result you will see in the enclosed appeal, which document we have circulated among such men of science as were catalogued in the "Naturalist's Directory." We find ourselves almost penniless. Our city is too well drained of its resources to afford more than a few scanty crumbs of aid. What response will be made to our petition we do not as yet know; certain it is that if this machinery fails we shall try some other. Our fortune, by its very hardness, rouses and stimulates us. We are very anxious to have some building of our own, however humble, rather than multiply risks by sharing with other organizations the common shelter of one roof. We feel better to-day, because no part of our loss is to be charged upon our own want of forethought or immediate care.

Our present location might again serve us were it not for public demands and interference. The walls of our building are as good as when first built; but the city, in making the street in front of us wider, cuts off about 20 feet of our building, reducing the dimensions of our land too much to leave the rest of use to us. I need scarcely add that, under the most favorable terms of sale, we cannot close our business matters up to have more than $2,500 remain above our mortgage debt.

But we ought not to tax your patience further. We shall be most grateful for your sympathy, suggestions, aid. Situated as we are, there is not another institution of science that has been forced to record two such terrible chapters of misfortune. But we mean, if Providence blesses our labors, to make it true that no local society of natural history shall leave in years to come a better chapter of hard-earned prosperity and fame.

[NOTE.—We are happy to state that this society is again in a flourishing condition, and that permission has recently been given to it by the city government to occupy, free of charge, rooms in the new city hall building; also, that the Smithsonian Institution has presented it with another very complete set of its duplicate specimens of natural history.—J. H.]

From Josiah Goodwin, secretary and editor of the Bath and West of England Society for the Encouragement of Agriculture, Arts, Manufactures, and Commerce.

BATH, *September* 3, 1866.

On behalf of the president and council of the Bath and West of England society, I have the honor to acknowledge the safe arrival of the several books enumerated in the invoice numbered 804*a*, 1866, which I beg to enclose receipted; and I have much pleasure in conveying to the honorable the officers and Regents

of the Smithsonian Institution the assurance that the president and the council of the Bath and West of England society entertain not only a very high sense of the valuable services conferred on the scientific world by the labors and publications of the Smithsonian Institution, but they cannot too highly applaud the enlightened liberality which has actuated the conductors of the Smithsonian Institution in the establishment of such an admirable system of organization for facilitating the mutual interchange of the publications of the learned and other societies in various parts of the great continent of America and the United Kingdom of Great Britain and Ireland.

Acting in a reciprocal spirit, I have much pleasure in transmitting, through your recognized agent, several volumes of the Bath and West of England society's journals, in order to complete the set in the library of your Institution, more especially as the earlier volumes can now be obtained only very rarely, as the society's stock is entirely exhausted.

From Dr. Brehm, the director of the Zoological Gardens.

HAMBURG, *September* 11, 1866.

I am in receipt of your letter dated the 2d of last month, in which you state that a specimen of the American great horned owl is offered for the acceptance of the zoological society of this city, by the Smithsonian Institution; and I have the satisfaction of stating that the bird has arrived in good health and condition, and the society is very much obliged, and will do itself the pleasure of returning the compliment if you will indicate in what manner it can be done.

If I might further intrude on the kindness of the Institution, it would be to say that some of your common finches *(Fringillidæ)* would be very acceptable, as the birds usually imported are only such as, e. g: *Cardinalis virginianus*, *Spiza cinis*, *Astragalinus tristus*, and *Cocoborus ludovicianus.* But we get overdone with these birds of dealers, and which are popular with private purchasers, who do not value the less externally attractive and common birds which I am anxious to possess. Some of the *small* owls I should also like to have from America, together with any of your ducks, *(Anas,)* excepting the "summer duck," which, for the same reason as I have above given in regard to other birds, are imported into Europe in quantities.

It is remarkable that the "snow goose," though abounding in the United States in any number of thousands, is not in any European zoological garden. Will you please to think of me with special attention with regard to this bird?

From the Chicago Academy of Sciences.

CHICAGO, *February* 11, 1867.

The undersigned, trustees of the Chicago Academy of Sciences, desiring to signalize in a more special manner their sense of the great obligations the academy is under to the Smithsonian Institution, have caused a list to be made of its recent donations to their library and museum, and take this method of expressing to you their sincere thanks, not only for these books and specimens, but in general for the fostering care with which the Institution has treated, from its inception, our attempt to establish a strictly scientific museum here in the west.

Very respectfully, your obedient servants,

GEO. C. WALKER.
W. E. DOGGETT.
E. G. McCAGG.
J. YOUNG SCAMMON.
H. G. LOOMIS.
E. W. BLATCHFORD.
DANIEL THOMPSON.

Report on an improved system of numeration, by W. B. Taylor, Esq.

UNITED STATES PATENT OFFICE,
Washington, March 22, 1867.

I have examined the paper referred to, on the subject of an improved numeration for arithmetical operations, and have, respectfully, to offer the following remarks: The proposal is simply to interpolate six additional "digits" (if the term may be allowed) between the nine and the ten of our common arithmetical scale, in every order or place of figures; in other words, to substitute a senidenary for the received denary radix of numeration. This suggestion has been made, I believe, more than once before. In 1859, Mr. J. W. Nystrom, of Philadelphia, published an essay on what he called the tonal system, (ton being the name he assigned to the senidenary *ten*,) advocating the adoption of the number 16 as the basis of a universal arithmetic and metrology.

All who have given the subject of weights and measures much consideration will agree in the proposition that a scheme of continual bisections and doublings would prove a great convenience in all the operations of concrete arithmetic, and were it not for the enormous labor of a reconstruction, and the great time required for its general introduction among civilized nations, some such reform might be accepted as advantageous or desirable.

So early as the beginning of the last century, the illustrious Leibnitz elaborated a scheme of binary arithmetic, (whose only characters were 1 and 0,) and published a treatise in its exposition and support. A paper of his upon the subject will be found in the Memoirs of the Academie Royal des Sciences for the year 1703, page 85, in which he says he had himself employed this ratio of computation for many years, and that he regarded it as "la perfection de la science des nombres;" an opinion which, from such an authority, is entitled to very high respect.

It may well be questioned, however, whether the senidenary scale favored by your correspondent would fulfil the true desideratum—*a minimum of arithmetical labor.* There are considerations tending to show that even our present *denary* ratio is too high for the most complete and general facility. In balancing the two opposite conditions of conciseness of expression, and simplicity of construction, it must be borne in mind that while the number of places required to express a given value is diminished, simply as the *logarithm* of the radix increases, the mental labor required in using any scale is increased in a considerably higher ratio than the arithmetical increment of the radix; probably in a geometrical progression, or as some low power of the base. I am inclined to believe, therefore, that as between the binary and senidenary systems, the former is decidedly to be preferred; that the economy of places or of expression in the latter would prove but a trival compensation for its much larger range and variety of symbols and the far greater complexity of all the tables and processes necessary in its employment.

For all popular uses, either the quarternary or octonary scale would probably be found much more convenient than either of these suggested extremes, and certainly much more available for the distribution of weights and measures.

In 1719, Swedenborg published an Octonary Computus, and a project of an octaval system of weights, measures, and coins. It is said that Charles XII, of Sweden, had contemplated the experimental adoption of the scheme not long before his death, in 1718.

It may not be considered irrelevant to here briefly compare the four different scales above mentioned with our established scale, in point of expressiveness.

Scale of comparison.

Scale.	Radix.	Logarithm.	Approximate No. of places.	Expression for the present year.
Denary	10	1.	1	1.867
Senidenary	16	1.204	$\frac{5}{6}$	.743
Octonary	8	.903	$\frac{10}{9}$	3.513
Quarternary	4	.602	$\frac{5}{3}$	131.023
Binary	2	.301	$\frac{10}{3}$	11.101.001.011

Or to compare them in the expression of very large values, as for example, of such a sum as the number of grains of sand required to constitute a globe as large as our earth, (which, assuming 10 millions of grains to the cubic inch, would not exceed 659 quintillions, an expression requiring 33 places of figures,) we should find that the senidenary scale would require 28 figures, (a reduction quite insignificant,) the octonary would require 37 figures, (an excess equally insignificant, with only half the number of digits, and probably not one-fourth the difficulty,) the quarternary 55 figures, and the binary 110 figures.

In conclusion, I would express the opinion that the arithmetical scale suggested by your correspondent does not promise a convenience which would justify the subversion of the existing system of enumeration in its favor.

From Count de Lulk, President of the St. Petersburg Academy of Sciences.

St. Petersburg, *May* 13, 1867.

Having received, through the kind attention of his excellency General Clay, the letter which you did me the honor to address to me under date of the 25th of March last, from the city of Washington, I lost no time in communicating its purport to the Imperial Academy of Sciences. That body has accepted, with the most lively acknowledgments, the offer which you make, in the name of the Smithsonian Institution, to enrich the museums of the academy with the gift of duplicates of the objects of natural history, collected in the Russian possessions in America, as well as of those which M. Bischoff shall have an opportunity of collecting in Kamtschatka and the province of the Amour.

At the same time I deemed it my duty to address to General Korsakoff, governor general of Siberia, a request that he would have the goodness to give such orders that M. Bischoff shall find, during the expedition which he contemplates, assistance and protection on the part of the local authorities. By an official despatch of the 25th of April, M. Korsakoff informs me that he has written on this subject to the governors of the provinces which M. Bischoff has the intention of visiting, and has, at the same time, conveyed to me an open order (in the Russian language) which it will be proper that M. Bischoff shall carry with him and produce to the local authorities in case of need, that he may secure their protection and assistance, be enabled to procure from the magazines of the state provisions at the legal rates, and be received on board the vessels of the empire. This document I have the honor of transmitting with the present communication, and beg, sir, that you will accept the assurance of my most distinguished consideration.

From H. Zisgenbals.

LEIPSIC, *May* 17, 1867.

Enclosed I send you the prospectus of the Schlagintwait collection of ethnographic heads of India and higher Asia, which, in view of the purpose now entertained of forming a comprehensive museum of such representations, cannot fail to be of interest to the Smithsonian Institution.

The price of the collection is, as has been already stated, somewhat high, and is established at the following rates:

1. Single heads, according to the choice of the purchaser, for 11 thalers.
2. At least 25 heads taken at one time, at 9 thalers.
3. The complete collection, 275 heads and 37 impressions of hands and feet, taken at one time, 2,348 thalers.

In case of a commission for the above purpose I would hold myself in readiness to superintend the transmission in the best and most expeditious manner.

From W. Alfred Lloyd.

HAMBURG, *May* 25, 1867.

The *sparrows* will be sent in about two months from this date, when the young birds born this spring will be strong enough for travelling. They are not very easy to keep in captivity, and I must try to find out by previous observation what will be the best manner of forwarding them. You shall, of course, have due notice and proper instructions, and I will place them in the care of a trustworthy person, to whom a premium can be offered, varying in amount according to the number delivered alive and in good health. This is the plan I adopt with regard to the transport of living aquarium animals, and thank you very much for kindly trying to send me some. I mentioned sea anemones and madrepores, they being easier to send alive than some other animals, but I should be glad to have any American invertebrata, particularly marine, as I try to make the aquarium of our society a kind of museum of the lower aquatic forms of life. I think I did send you a pamphlet containing a list of those I have already obtained, chiefly from England and the north of Europe, and I am now desirous to get things from places further afield. I believe many of your marine crustacea might be forwarded with no very great amount of difficulty, but the only examples I have yet obtained are *Cenobita Diogenes*, from Cuba, and *Limularpolyphemus*, from New York. I have still some of the last named, but they are too big for my accommodations, and I am anxious to see very young specimens—say a couple of inches long. Last week I almost got some crabs from the South Sea islands. They appear to be situated somewhere about grapsus or gonoplæ. These three forms of crustacea reached Europe alive because of their habit of living much out of water, not usually *immersed* in fluid, but only kept damp, so that the fact or accidence of their own avoidance of being kept actually below the surface of the water caused their gills to be sufficiently aerated on the voyage, as it is evident that thin films of water presented to the atmosphere are more quickly oxygenated and acted upon than large masses, because of the presentation of greater surfaces to the action of the atmosphere, just the same comparing together dissimilar processes that a lump of sugar placed in water as a solid lump takes a much longer time to dissolve than if the same quantity were powdered, because when in the form of powder the water has an infinite number of surfaces to act upon all at once. For this reason I keep all difficult marine animals in shallow water. A cubic foot of fluid, arranged as a cube, presents to the atmosphere a surface of 144 square inches, whereas, if the same cubic foot be spread out so the depth is but three inches, the surface presented is 576

inches, and the amount of oxygen absorbed by the atmosphere in contact with it and the health of the animals immersed in it (always supposing they have enough space in which to move) is according to the arithmetical expression of the case. Even deep-sea creatures obtained from the greatest depths to which dredges and sounding lines have ever penetrated try to get to the *surface* of the aquarium they are placed in, to seek the air which the enormous pressure gave them in the waters they inhabited in nature, and appear to suffer no inconvenience by the removal of that pressure, their tissues being vascular and permeated by the water on all sides. I trouble you with these particulars as being useful hints in the sending of any aquatic animals, as sailors and others are so apt to keep them in deep water, i. e., deep water relatively to the surface exposed afforded by the vessel they are brought in. I have often thought that a large tub containing masses of rough cleaned sponge, (such as is used for stable purposes,) would answer well in bringing over some crustacea, and perhaps sea anemones. Some small holes should be bored in the side of the tub about three inches from the bottom, and then, if a quantity of sea-water were daily or oftener poured over the sponge and animals, it would find its way out at the holes and leave the sponge saturated with moisture. Each mass of sponge would be a kind of lung perforated with openings in all directions, and the fluid contained in the sponge would thus have a very large surface exposure to the surrounding air, and the crabs would climb upon and absorb it, while the three inches of water below would effectually prevent desiccation. Twenty or thirty small crabs so brought to Europe in a tub of about four feet diameter, covered over the top with a net, would be very nearly in the condition, chemically speaking of, as many birds or other lung-breathing creatures. The sponge too would, I think, prevent injury to the animals by the motion of the ship. We know far too little of the habits of invertebrate aquatic forms of life from parts of the world distant from us, as we have not given sufficient consideration to the proper means of transporting them. What is wanted is not only water but *air in the water*, and if on board ship the appliances are somewhat rude, so that the fluid cannot be kept as pure as it might be kept on land, then shallowness and the presentation of great surfaces of fluid to the purifying influences of the atmosphere are the best means of getting over the difficulty. We shall be very thankful for the promised *menopoma.*

From W. Alfred Lloyd.

HAMBURG, *July* 13, 1867.

By the steamer Borussia, leaving here this evening, the "Zoologische Gessellchaft," of Hamburg, sends for the acceptance of the Smithsonian Institution at Washington a collection of upwards of 300 living sparrows, in accordance with a wish expressed by you, as you desire these birds to multiply in your country that they may consume the insects that devour corn, vegetables, and fruit growing in the ground. Will you please report on their arrival and say how many, if any, reached you alive; then this society will pay the man in charge a proportionate premium for himself. The freight is free between our two Institutions by all the vessels of the Hamburg New York company. Please return the cages, and, if you wish, we will send more in them, *and continue to forward you supplies till we succeed, if success be possible.* Sparrows from England have been sent, after some trials, to Australia, and they are there thriving, I believe. If any ill-luck should happen to the present consignment, please try to find out the cause of it, in order that in renewing our attempt we may learn from experience of the past. I have heard something of the value of transporting such birds to long distances confined in small cages, with two or three in each, but no *reason* was given for it, and therefore I cannot see why such a system should be

right or wrong; but if you find a good *cause* for it, let me know and I will adopt the plan, or any other.

You were, in your letter of April 24th last, so kind as to say you would endeavor to forward my wish in procuring from America some living marine animals for our aquarium here, and I should be glad to know what success you have yet met with. Some weeks ago I sent you a letter setting forth at full length my views on the transport of non-lung-breathing animals, and I trust that the explanations I ventured to trouble you with may be of some service in getting over difficulties. We know very little of non-European zoophytes in a living state, and, as I may have told you, American sea anemones have been brought over *only once*, though such animals from Britain have several times been sent to your country and to Australia.

I am *exceedingly anxious* to obtain some of your Helian thoid polypes, your sea anemones and madrepores; and no matter how common they may be with you, they are sure to be interesting and valuable to me, unless it is positively known beyond all doubt that they are identical with European species, and even then the very fact of the identity would be of interest. *So please send me any.* Of course you have got Gosse's "Actinotoba Britannica," 8vo, 1860. It is the text-book for British Actineas and Madrepores; and I am told that Rhodactinea is exactly the same as our Act. mesembry anthemone. I should like to prove this. I have also heard that our Actinotoba dianthus is "very near your M. marginatum," and this, too, I should like to clear up.

Arachnactis, the only swimming anemone known, is reported to be very abundant with you; it finds a place in the lists of our British fauna, but I do not know any one who has ever seen it, and I fear it is too small and delicate, and too near in texture and habit to the Acalaphæ to be brought here alive. *Bisidiam* and *Haleampa*, too, are two of your minute forms I should like to get.

Our two commonest British corals, *Caryophyllea* and *Balamphyllea*, are exceedingly hardy in transport, and if your stony corals are anything like ours the sending them over is a matter of no great difficulty.

We have but one really denotoid coral in Britain, *Laphohelia prolifera*, and its corrallam even is very rare indeed, and no British naturalist has ever seen it alive. Tropical (American and other) branching corals are constantly being brought to Europe by tons weight, but never once has a single living specimen been imported in good health. Lately I went to much expense in trying to get some from the Navigators' islands, but they all arrived without a particle of fleshy matter on them. You may judge from this what a great prize I should deem an *Astrangia* colony here in Hamburg, and this is found in abundance, I believe, in Massachusetts bay. It is right to name the name of the man who for the first and only time brought sea anemones from your country—Captain H. W. Wendt. In my blazing zeal I have had his photographic portrait framed; and, common sailor though he looks, he is in my eyes a greater man than all the political fellows who go raving up and down various countries. The species were *Phymactis florida* and *Phymactis pluvia*, from Iguazee, in Peru, and described in Dana's great work in quarto and folio on Captain Wilkes's United States exploring expedition.

The Echinodermata of any kinds, hard or soft, would, I fear, not travel, but I need not say how much I should value a living *Echinarachinus*, of which only one example of one species (E. Placenta) has ever been found in Britain. With you it is very common.

Fishes from America are not to be hoped for, I am afraid, though I have got two alive, (*Pimelodus catus* and *Leneiscus pygmaeus.*) But some of the crustacea might, I imagine, be got over alive; for example, *Homarus Americanus*. And judging from it, I should imagine your edible crabs and your soldier crabs to be different specifically from ours.

But pray assist me in preventing the importation of *Limulus polyphemus*

(horseshoe crab,) which come over here in such numbers that lately I have with them stocked all the marine aquaria of England and the continent of Europe, and I do not know what to do with those I now have over. I do not like to see the poor things dying by inches, and my mind revolts at plunging animals full of life and health into spirits. It would be well if *Limulas* were less hardy.

From the Museum of Natural History of the National University of Greece.

ATHENS, *August* 12, 1867.

We have learned, through M. Rangabé, our envoy extraordinary and minister plenipotentiary near the government of the Union, that the directorship of the Institution of Smithson is desirous of entering into relations of exchange with our museum of natural history, with a view to obtaining the natural productions of Greece. We lose no time in expressing the pleasure which this information has given us, and the gratification we shall experience in forming and maintaining such relations, which cannot fail to be of great advantage to our own museum, inasmuch as our collections are at present but scantily provided with objects pertaining to the natural history of North America. As regards duplicates of the objects of our own country, we have in readiness for offering to the Institution: a series of fossil bones of different mammifers (Hippotherium grande; Rhinoceros partygnathus; Sus erymanthius; several species of antelope, &c., &c.,) of the pleocene formation of Pikermi, in Attica; a collection of impressions of fossil plants of the eocene formation of Koumi, in Enbir; preparations of several kinds of birds of Greece; eggs of different Greek birds; marine shells, fresh-water and terrestrial.

We beg to be instructed as to what the Institution would desire, or rather what it would prefer to receive in the first instance, in order that we may be able at once to make a first remittance. We should be glad, at the same time, to know by what channel, by what means, and to what address our remittances must be forwarded. It would be esteemed a favor if the authorities of the Institution would inform us in a compendious note what objects it possesses in duplicate and at its disposal for exchange, so that we might indicate in turn our own desiderata.

We have the honor of subscribing ourselves, with assurances of the most distinguished consideration,

TH. DE HELDREICH,
Conservator of the Museum of Natural History.

HEHITZOPOULOS,
Ephor of the Zoological, Mineralogical, and Geological Collections of the Museum of Natural History of the University.

From Professor Laboulaye, of the Institute of France.

PARIS, *September* 4, 1867.

I have received, through M. Bossange, the case containing 174 volumes of educational books, which you had the goodness to send me. These books form the admiration of all who take an interest in education, and I hope that France will profit by this example. We have excellent things at home by which you in turn might profit; but we have seen nothing comparable to your "Reader," your "Object Lessons," your "Graphics," and your "Geographical Series."

I send you a letter for each of the editors who has been kind enough to make

me a present; and I avail myself of this opportunity to say to you how much I am touched by the proof you have given me, on this occasion, of good will. You have treated me as a compatriot, and, sooth to say, there is no Frenchman who is more American than myself.

[The works referred to were presented by American publishers of school books at the request of the Institution.—J. H.]

From D. G. Lindhagen, perpetual secretary of the Academy of Sciences of Stockholm.

STOCKHOLM, *November* 4, 1867.

I have had the pleasure of receiving, in behalf of the Academy of Sciences at Stockholm, your letter of the 29th of May last, accompanying your remittance, through M. Flügel of Leipzic, of a collection of very rare birds of the Arctic regions of your continent—a collection which your distinguished Institution has had the goodness to present to our academy.

The package arrived in the month of August, during my absence on certain commissions of the academy, and was transmitted to M. Sandevall, intendant of the national museum of natural history, who presented it to the academy at its first meeting in autumn, pronouncing its contents to possess great value for the museum.

Permit me to convey to you the thanks of the academy for this acceptable donation.

From John Gould, esq.

LONDON, *November* 25, 1867.

I beg to thank you most sincerely for your kindness and liberality in sending from time to time for my inspection, through Mr. Lawrence, of New York, specimens of humming-birds belonging to the Smithsonian Institution, which he has designated as new species. By these acts of condescension you are greatly aiding the cause of science, since it is only by the actual comparison of such examples with the older known species of this extensive family in the collections of this country that the fact of their being new can be satisfactorily determined.

From S. P. Mayberry.

CAPE ELIZABETH, MAINE, *January* 4, 1868.

I am very much pleased with the selections in your reports, and hope that some means may be taken for their more extended circulation. While at a summer resort, Rye Beach, New Hampshire, of some celebrity, attention was called to the gradual approach of the sea upon the land. Some 20 rods below high-water mark, at an exceeding low tide, may be seen the stumps of quite large trees embedded in the sand, and from the general appearance one would suppose that the trees had been felled from those stumps. I made inquiry of the oldest inhabitants if they had any information relative to them; they had none; that, in their time and that of their fathers', these had been noticed, seeming not much further out to sea than at the present time. There is no growth within 800 yards. The country around has been settled since 1623. About two miles from this used to be a fine sand beach, which has disappeared. The inhabitants thought

the constant play of the sea had worn it, but from what I saw I rather inferred that the gradual approach had not been noticed, and I believe at some other points there is unmistakable evidence. If these facts are of any use to science, they are at your disposal.

[The facts presented in the above communication are very interesting, in connection with similar observations at other points along our coast. They indicate a movement in the strata of the earth.—J. H.]

From Lucien Pratt, professor of physics and chemistry, University of San José, Costa Rica.

SAN JOSÉ DE COSTA RICA, *February* 8, 1868.

We have received through M. the minister of public instruction a magnificent collection of the scientific memoirs of the Smithsonian Institution, which will form the most precious part of the library of our university. I am authorized to keep it in the laboratory, and I can assure you that, as far as we are concerned, the object of the publication will be fully attained. It will essentially serve to augment our stores of knowledge, especially in meteorology and geology. The minister has, I believe, already written to the Smithsonian Institution in the name of the Costa Rican government. Permit me, sir, specially to offer you my own acknowledgments and to say how greatly I felicitate myself at seeing our laboratory placed in the relationship of exchange with one of the first scientific bodies of the world. Regarding neither the paucity of the present population of the country, nor the necessarily embryonic state of the University of San José, you have looked only at our disposition to labor, to take part in the scientific movement of the great nations, and you have treated us with a liberality for which I know not how to express my gratitude.

I was about to solicit an order to send you a collection of the ores of the country and of the most characteristic rocks among those which I have thus far been able to collect, when this very order was issued to me. I have, therefore, prepared two small cases, enclosing 39 select specimens of the ores of gold and silver of Costa Rica, as well as of some eruptive rocks and principal limestones known in the country.* These two cases I propose to despatch by the mail of day after to-morrow.

The specimens of ores of gold and silver are accompanied only by a designation of the locality; by the next post I shall have the honor of addressing you a copy of an official table drawn up by one of the judges of mines, in which you will find all the indications relative to the value of the ores. I send no table of analysis, because this analysis would apply only to isolated specimens or at most to an average of specimens, and would never have the practical signification of the results obtained by the *exploitation.* Neither have I sent any specimen of the enveloping stratum, because the specimens which I have at the university have been taken rather too near the surface, and it is impossible to recognize in the decomposed rock any mineralogical character which would authorize a determination respecting the formation itself. It should be added that I have not yet been able to proceed to a study of the conditions of the bearings on the spot. As soon as I shall have found time to make a geological reconnaissance of the principal Costa Rican mines, I will send you a statement of my observations, and will submit to you at the same time specimens of the rocks in support of my determinations. It would be very interesting to see whether the law of Humboldt applies to Central America, and whether it be really necessary always to

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* These specimens have been received at the Institution.

seek the precious metals at the point of contact of the porphyry and trachyta. I do not doubt this law as far as the great formation of South America is concerned, but it appears to me that here and in all South America the upheavals have taken place at several intervals and relatively on a small scale, so that all is confounded.

You will excuse, I trust, sir, the meagreness of our remittance, in consideration that it is barely two years since the university has possessed a laboratory. The work of organization, indeed, is not yet fully completed. I have no preparator, and the most advanced of my pupils have had less than two years' tuition. I have a number of schemes in view which can only be realized by degrees. In all that relates to a serious study of the country, it was impossible to commence anything before providing assistants, without whom an isolated explorer, however earnest his purpose, would find himself reduced to two hands and 12 hours' labor per diem. The government, by which the laboratory has been established, has always protected us with a liberality sufficiently indicative of its enlightened views, and I hope that ere long myself and my disciples will be enabled to give far other proofs of our existence than a scanty remittance of some 39 specimens.

It is possible that we shall remain for some time among the poorer correspondents of the Smithsonian Institution, but have the goodness to believe that we shall be among the most zealous, and of the number of those always most ready to contribute, according to our resources, to the noble objects which the Institution holds up to view.

BIOGRAPHICAL NOTICE OF CHARLES COFFIN JEWETT,

(FORMERLY ASSISTANT SECRETARY OF THE SMITHSONIAN INSTITUTION, IN CHARGE OF THE LIBRARY.)

BY REUBEN A. GUILD, OF BROWN UNIVERSITY.*

Again we are called upon to mourn the loss of a distinguished man, whom death has suddenly removed from earth in the prime of life and in the midst of his accustomed duties. We refer to Professor Charles C. Jewett, superintendent of the Public Library in Boston, who died at his residence, in Braintree, yesterday morning, at half-past 1 o'clock, after a brief illness of ten hours. On Wednesday, we are informed, he was at his post in the library, attending to his work as usual, until 3 o'clock in the afternoon, when he was seized with a sensation of numbness in one hand, which proved to be paralysis. He remained conscious for a time, and after having had medical attendance, requested to be carried to his home. On the way he became insensible, and thus he continued until his death.

Mr. Jewett was born in Lebanon, Maine, on the 12th of August, 1816. His father, the Rev. Paul Jewett, was a Congregationalist clergyman of Salem, Massachusetts, who graduated at Brown University in 1802, in the same class with the late Hon. Henry Wheaton, LL. D., author of "Elements of International Law." He was a tutor in this institution from 1806 to 1809, and was afterwards offered a professorship, which he declined, preferring the labors and responsibilities of the Christian ministry to those of any other calling or profession. He was a man of talents, of accurate learning, of cultivated taste, and of very retiring habits. In the education of his children he took unwearied pains. His eldest son was, until recently, a well-known and enterprising publisher and bookseller in Boston; the second is the one whose loss we to-day deplore, and a third was for several years a professor in Amherst College.

Mr. Jewett passed his early life in Salem, graduating at the Latin School in that place. He entered Dartmouth College in 1831, but transferred his connection, in his sophomore year, to Brown University, where he graduated in the famous class of 1835. He spent two years or more in teaching at the Uxbridge Academy, and subsequently studied at the Theological Seminary in Andover. Here he devoted himself chiefly to Philology, and especially to the oriental languages and eastern antiquities, in which departments of knowledge he attained great proficiency. Indeed, according to the testimonies of the late Professors Stuart and Edwards, few students, if any, had in these departments excelled him. His commencement address at Andover attracted universal attention, and was greatly admired on account of the elegant style in which it was written, and the thorough acquaintance with oriental subjects which it evinced on the part of the author.

During his residence at Andover, Mr. Jewett was for a year and upwards the librarian of the seminary, and he assisted Mr. Taylor in the preparation of a catalogue of the books. At this time he was intending to spend several years, and perhaps his life, in the East as a missionary, and he had, accordingly, at the close of his theological course, marked out for himself an extensive course of study and research. He had been offered facilities for the accomplishment of his wishes such as few scholars, in this country at least, had ever enjoyed. When ready to embark, so slight a circumstance as the misdirecting of a letter to inform him when the vessel in which he had taken passage was to sail, changed his

* From the Providence Evening Press, Friday, January 10, 1868.

whole course of life. The vessel sailed without him, and he took charge for a year of "Day's Academy," so-called, in Wrentham, Massachusetts. Here we first made his acquaintance as a pupil, and we shall never forget his genial manners towards all, and his cordial affection for those especially whom he instructed. In 1841 he was appointed librarian of Brown University, and he entered upon his duties in the month of October. He at once set himself to the task of rearranging the books, then numbering about ten thousand volumes, and of preparing a catalogue of the same. For this kind of work he had an uncommon aptitude. The catalogue was published in 1843, and attracted much attention, being favorably noticed in the North American Review, and in other periodicals. Especial care was now given to this department of the University, and a new era in its history was inaugurated.

Soon after the publication of the catalogue, Mr. Jewett was elected professor of modern languages and literature in the university. He immediately embarked for Europe, where he spent two years and a half, principally in France, Germany, and Italy, devoting himself to the acquisition of the languages of these countries, and making himself familiar with all the principal libraries. During his residence abroad, Professor Jewett made valuable purchases of English and classical books, under the direction of the library committee. He was also intrusted with large commissions by a gentleman of the corporation, for the purchase of standard books in the three principal modern languages of Europe. These purchases, amounting to seven thousand volumes and upwards, were made with singular skill and fidelity; and the accessions thus secured now constitute the choicest treasures of the library.

Upon his return from Europe, Professor Jewett devoted himself to his college duties as teacher and librarian, until March, 1848, when he resigned his position at Brown to accept the place of assistant secretary and librarian of the Smithsonian Institution at Washington. He entered upon his new duties with enthusiastic ardor, and with all the fondness and capacity for hard and persevering labor for which he had been pre-eminently distinguished. He was doomed, however, to disappointment in his efforts to build up a great national library, and thus to carry out what he understood to be the expressed wishes of Congress in regard to the expenditure of the Smithsonian funds.* The controversy between science and literature, as represented by Professors Henry and Jewett, attracted great attention at the time, and subjected the latter to trials which fully entitled him to the sympathy that literary men so cordially gave him. But of the merits of this controversy we do not intend here to speak. Although unable, as already stated, to carry out his plans, Professor Jewett did much to promote bibliographical studies and the success of American libraries. His "Notices of Public Libraries in the United States," which was printed in 1850, was widely circulated and met with very general favor. He also perfected a system of cataloguing, by stereotyping separately the title of each work in a library, thus combining economy with accuracy. This system, indorsed by Edward Everett, Joseph G. Cogswell, Charles Folsom, Samuel F. Haven, Edward E. Hale, and George Livermore, was published under the auspices of the Smithsonian Institution, together with rules and examples for the proper cataloguing of books.

When it was decided to establish a great public library in Boston, Professor Jewett, by common consent the ablest bibliographer and most accomplished librarian in the country, was selected as the one of all others to superintend its affairs. Although offered an honorable position in our oldest university, and the presidency of a western college, he cheerfully accepted the place urged upon him by the trustees of the public library. The library building was dedicated with appropriate ceremonies on the 1st of January, 1858, and in October following the

* The wishes of Mr. Jewett in regard to a library at the seat of government worthy of the nation, are now being realized by the action of Congress, through the influence of the Smithsonian Institution, though not at the expense of its funds.—J. H.

first catalogue of books was published. For more than 10 years Mr. Jewett has thus been identified with the best interests of learning in the metropolis of New England. The catalogues which he has prepared, and the rules for the government of the library which he has suggested, have served as models for similar libraries in all parts of the country. To his thorough and systematic knowledge, and to the faithful performance of his duties, the citizens of Boston are largely indebted for the rapid growth and complete success of what seems destined to be *the library* of the land.

The early death of such a man must be regarded as a public loss. What shall we say, alas! for the loved wife and children who survive him, and for those who enjoyed his friendship, and who knew him in the most intimate relations of private life? For such, it is a consolation to know that his daily walk and conversation was a beautiful illustration of the Christian's faith; and that the heavenly smile which rested upon his features in the calm repose of death was but an index to the soul that had ceased to animate them forever. The loss of such a man, viewed in its religious aspects, is indeed "gain."

BIOGRAPHICAL NOTICE OF WM. HENRY HARVEY, OF DUBLIN.

By Professor Asa Gray, of Harvard College.

[This biography is republished from the American Journal of Science and Arts as a tribute to the memory of a most valued collaborator of the Smithsonian Institution.—J. H.]

William Henry Harvey, whose lamented death was announced in the last number of this journal, (p. 129,) was born at Summerville, near Limerick, Ireland, on the 5th of February, 1811. His father, Joseph M. Harvey, was a highly respected merchant in that city, and a member of the Society of Friends. William Henry was, we believe, the youngest of several children. He received a good education at Ballitore school, an institution of the Friends, and on leaving it was engaged for a time in his father's counting-room, devoting, however, all his spare time to natural history, his favorite pursuit even from boyhood. He made considerable attainments in entomology and conchology, and in botany he early turned his attention to mosses and *algæ*. To the study of the latter, in which he became pre-eminent, he was attracted from the first by the opportunities which he enjoyed on the productive western coast of Ireland, the family usually spending a good part of the summer at the seaside, mostly on the bold and picturesque shore of Clare. As the late Sir William Hooker's bent for botany was fixed by his accidental discovery of a rare moss, which he took to Sir J. E. Smith, so in turn was Harvey's, by his discovery of two new habitats of another rare moss, the *Hookeria lætevirens,* which led to a correspondence with Hooker, and to a life-long mutual attachment of these most excellent men. Encouraged by his illustrious friend and patron, Harvey sought some position in which he might devote himself to science; and it would appear was selected by Mr. Spring Rice (the late Lord Monteagle) for the post of colonial treasurer at the Cape of Good Hope; that by some accident the appointment was made out in the name of an elder brother, and an inopportune change of ministry frustrated all attempts at rectification. There was no other way but for the brother to accept the undersigned appointment, and take the young botanist with him to the Cape as his assistant. This was done, and the brothers sailed for that colony in the year 1835. But the health of the elder brother suddenly and hopelessly failed within a year, and he died in 1836 on the passage home. William Harvey's appointment to succeed his brother had been sent to the Cape while he was on his homeward voyage; he immediately returned to his post and fulfilled its duties for three years, devoting his mornings to collecting and his nights to botanical investigation, with such assiduity that his health also gave way, and he was compelled to return home in 1839. The summer of the next year found him re-established and on his way to the Cape for the third time. But he could not long endure the sultry climate and the intense application; with broken health he came back in 1841 and gave up the appointment.

After two years of prostration and seclusion he was well again; and in 1844, on the death of Dr. Coulter, he was appointed keeper of the herbarium of Trinity College, Dublin. The most important portion of the herbarium then consisted of the collections, yet unassorted, made by Coulter in northwestern Mexico and California. Harvey generously added his own large collections, for which he was allowed fifty pounds a year in addition to a slender salary, and he proceeded to build up the herbarium into a first-class establishment. The professorship of

botany in the college, which was pretty well endowed, fell vacant about this time, and the college authorities, wishing to elect Harvey to the chair and so to combine the two offices, conferred upon him the necessary degree of M. D. But it was contended that an honorary degree did not meet the requirements, and so Dr. Allman, the present distinguished professor of natural history at Edinburg, carried the election.

Except for the slenderness of his salary, Dr. Harvey was now well placed for scientific work, the object to which he wished to devote his life, and he entered upon and pursued his distinguished career henceforth with an entire and well-directed energy that never flagged until he was prostrated by mortal disease.

He had already published, at the Cape in 1838, his *Genera of South African Plants*, hastily prepared, solely for local use, but no unworthy beginning of his work in Phænogamous Botany; and in his favorite department of the science he had brought out in 1841 his *Manual of British Algæ*, which he re-edited in 1849. He now commenced the first of the series of his greater works, illustrated by his facile pencil—for he drew admirably. The first (monthly) part of his excellent and beautiful *Phycologia Britannica, a History of British Seaweeds*, containing colored figures of all the species inhabiting the shores of the British islands, appeared in January, 1846, and the undertaking was completed in 1851, in three (or four) volumes, with 360 plates, all drawn on stone by his own hand. A similar but less extended work, the *Nereis Australis, or Algæ of the Southern Ocean*, which was begun in 1847, was carried only to 50 plates of selected and beautiful species.

In 1848, Dr. Harvey succeeded Dr. Litton as professor of botany in the Royal Dublin Society, to which belonged the botanic garden of Glasnevin; this required him to deliver short courses of lectures annually in Dublin or in some other Irish town, and provided a welcome addition to his income.

In 1848, at the request of his friend Van Voorst, the publisher, he wrote his charming little volume, *The Sea-Side Book*, the unsurpassed model of that class of popular scientific books; it was published in 1849, and has passed through several editions. In July of that year, having arranged a visit to this country, and having been invited to deliver a course of lectures before the Lowell Institute, he took steamer for Halifax and Boston, passed the summer and autumn in exploring the shores of the northern States, and in the society of his friends and relatives; for the late Mr. Jacob Harvey, still well and pleasantly remembered in New York, who married the daughter of Dr. Hosack, was his elder brother. In the autumn he gave an admirable course of lectures upon Cryptogamic botany before the Lowell Institute in Boston, and afterwards a shorter course at the Smithsonian Institution at Washington. He then travelled in the southern Atlantic States, continuing the exploration of our *Algæ* down to Florida and the Keys; and in May, 1850, he returned to Ireland.* Under the wise and liberal arrangements made by Professor Henry in behalf of the Smithsonian Institution, and with his own large collections augmented by the contributions which every student or lover of *Algæ* was glad to place in such worthy hands, Professor Harvey now prepared his *Nereis Boreali-Americana, or Contributions to a History of the Marine Algæ of North America*. The work is a systematic account of all the known marine *Algæ* of North America, but with figures only of the leading species. It was issued in three parts; the first part, the *Melanospermeæ*, in 1852, in the third volume of the Smithsonian Contributions to Knowledge; the second, the *Rhodospermeæ*, in the fifth volume; and the third, or *Chlorospermeæ*, in the tenth volume of the series published in 1858; and the three parts, collected for separate issue, compose a thick imperial quarto volume, of 550 pages of letter-press and fifty plates. The work remains the principal if not the only

*A notice of Dr. Harvey in the Athenæum states, quite erroneously, that "he also at this time made a tour around the shores of the Pacific, visiting Oregon and California."

guide to the American student of *Algæ*, and one of the most popular as well as useful of the very various contributions to knowledge which the well-managed bequest of Smithson has given to the world.

Before the last part of the *Nereis Boreali-Americana* was published, Professor Harvey had sought a wider field of scientific labor and observation. Obtaining a long leave of absence, and some assistance from the university in addition to the continuance of his salary, he left England in August, 1853, by the overland route for Australia, stopping at Aden and Ceylon to collect; he visited the east, south, and west coasts of Australia, as well as Tasmania. Taking advantage of a missionary ship which was to cruise among the South Sea islands, and which offered him unexpected facilities, he visited the Fiji, Navigators', and Friendly islands, touching also at New Zealand. Returning to Sydney he sailed to Valparaiso, which he reached much prostrated through over-exertion in a warm climate; and when recuperated he returned home by way of the Isthmus, arriving in October, 1856. The algological collections of these three laborious years, or the Australian portion of them, formed the subject of Professor Harvey's third great illustrated work, and one of the most exquisite of the kind, the *Phycologia Australica*, the serial publication of which began in 1858, and was concluded in 1863, in five imperial octavo volumes, each of 60 colored plates. All but the last century of plates were put upon stone by the author.

Upon Dr. Harvey's return, in 1856, from his long expedition, he found the chair of botany in the University of Dublin vacated by the appointment of Dr. Allman to that of natural history in the University of Edinburg, and he was at once preferred to the position which he had sought when younger and freer, and which he now occupied till his death. The exhausting duties of this chair, and of that which he still held in the Royal Dublin Society, undiminished by the transference to the Government Museum of Irish Industry, did not prevent Professor Harvey from entering with unabated ardor upon an undertaking of greater magnitude than any preceding one. This was the *Flora Capensis*, a full systematic account of all the plants of the Cape Colony and the adjacent provinces of Caffraria and Natal, in which he was associated with Dr. Sonder, of Hamburg. Three thick octavo volumes of this work have appeared, the last in 1865, including the *Compositæ*. Along with this Dr. Harvey—learning for the purpose another form of lithographic drawing—brought out, between the years 1859 and 1864, two volumes of his *Thesaurus Capensis, or Illustrations of the South African Flora*, comprising 200 plates of interesting phænogamous plants. A complete list of his publications would include several contributions to scientific periodicals, mainly to Hooker's Journal of Botany, and a few miscellaneous writings.

In April, 1861, Dr. Harvey married Miss Phelps of Limerick. If not robust, he was apparently in good health, in the full maturity of his powers, and, it was hoped, only at the noonday of his allotted course of usefulness. But ere the lecture season of that summer was over, an attack of hæmorrhage from the lungs gave notice of a serious pulmonary disease. Yet he seemed to recover from this almost completely; he resumed his stated work and gave his lectures as usual in 1863, and also in the spring of the following year, but with some difficulty. The winter and spring of 1864–5 were spent in the south of France, with only transient benefit. Returning to his home and his herbarium he worked on still at the Cape Flora, with cheerful spirit and feeble hands, until he could work no longer. Last spring he sought in Devonshire a milder air, and found a peaceful rest. "On Tuesday, the 15th of May, 1866, at the age of 55 years, he quietly breathed his last at the residence of Lady Hooker, the widow of his long attached friend Sir William J. Hooker, surrounded by kind and anxious relatives and friends, and was buried in the cemetery at Torquay, on Saturday the 19th of May."

Dr. Harvey was one of the few botanists of our day who excelled both in phænogamic and cryptogamic botany. In algology, his favorite branch, probably he has left no superior; in systematic botany generally, he had now an eminent position. He was a keen observer and a capital describer. He investigated accurately, worked readily and easily with microscope, pencil and pen, wrote perspicuously, and, where the subject permitted, with captivating grace; affording, in his lighter productions, mere glimpses of the warm and poetical imagination, delicate humor, refined feeling, and sincere goodness which were charmingly revealed in intimate intercourse and correspondence, and which won the admiration and the love of all who knew him well. Handsome in person, gentle and fascinating in manners, genial and warm-hearted, but of very retiring disposition, simple in his tastes and unaffectedly devout, it is not surprising that he attracted friends wherever he went, so that his death will be sensibly felt on every continent and in the islands of the sea.

GENERAL APPENDIX

TO THE

REPORT FOR 1867.

The object of this appendix is to illustrate the operations of the Institution by reports of lectures and extracts from correspondence, as well as to furnish information of a character suited especially to the meteorological observers and other persons interested in the promotion of knowledge.

MEMOIR OF LEGENDRE.

By M. Élie de Beaumont,
Perpetual Secretary of the French Academy of Sciences.

TRANSLATED FOR THE SMITHSONIAN INSTITUTION BY C. A. ALEXANDER.

It has been said that the distinctive stamp of our age is the aspiration after material well-being. Science is accused of having fostered this instinct by the numerous useful applications with which it has endowed humanity; and it is true that in our day chemistry, steam, electricity, have remodelled the face of the world. It is quite certain, also, that a scientific education better understood and more generally distributed has multiplied the number of those who, without having received from nature faculties of the first order, have yet proved capable of deriving from science great advantages as well for others as themselves. We may well suppose that even minds still more developed, seduced by the allurements of fortune or yielding to stern necessity, have sometimes deviated from the arduous paths of pure science into the more inviting paths of applied science. But we have seen also, and see daily, men of a more robust temperament who, listening only to the inspirations of genius, devote their whole existence to strenuous labors which, for the moment, will contribute merely to the increase of science; of which future generations alone can make useful applications; which will not be appreciated even in a manner somewhat general until long after the death of their authors; and from which those authors will themselves have derived no other enjoyment than the majestic and exciting spectacle of great truths covered as yet with an impenetrable veil to all eyes but their own, together with the consciousness of a duty fulfilled towards Providence, who has intrusted to them the instruments of the future progress of the human race.

Among those who seem to have been born to vindicate our age from an unjust reproach, and to exalt humanity in its own esteem, a high rank must be accorded to a geometer who occupied a place in this academy for nearly 50 years, who has enriched our publications with some of their most valuable contents, and bequeathed to future ages works of paramount importance; whose merit is every day more generally recognized, and whose memory awaits by just title an official testimonial of the sympathetic admiration which has survived him in the affectionate remembrance of all his colleagues.

Adrien Marie Legendre was born, September 18, 1752, in a condition of life which left to him the credit of being indebted to his own merit for all that he might eventually become. He finished in good season, at the college Mazarin, those solid classical studies from which he derived a lasting taste for the literature of the ancients, the happy fruits of which are to be recognized in the elegance, the purity, and the lucid conciseness of his writings. There also he commenced the study of mathematics under a highly distinguished master, the Abbé Marie, who failed not to remark his ardor and was struck with the perspicuity of his exercises. But a little time had elapsed after his retirement from college when the judicious professor publishing, in 1774, a treatise on mechanics, thought proper to embody in it several remarkable fragments derived from his disciple. The modesty of the scholar inclined him to shrink from designa-

tion, but the abbé felt it to be a duty to indicate to men of science the passages which had proceeded from the pen of the young Legendre, aged at that time 22 years. Among these passages is the definition of accelerative forces, distinguished by a precision and clearness of expression which seem sometimes to be among the happy privileges of youth. This definition is so natural, and now so familiar to scientific minds, that, when recalled, it is with difficulty conceived how it could ever have presented anything of originality and novelty. It is but just to say that it forms no exceptional feature in the work of the Abbé Marie, who, in many respects, was in advance of his age, and whose merit was not limited to that of having divined the talents of Legendre.

D'Alembert had said, with just foresight, that the fate of the new calculus (differential and integral) would depend on the reception it met with from the younger geometers; these therefore he sought to allure to the method in question, and which was as yet imperfectly comprehended, by the degree of esteem and consideration which he accorded to such among them as evinced a capacity for following it. He was not likely long to overlook the penetrating and precocious talent which disclosed itself in the young Legendre; and scarcely had the first limpses of genius given presage of what might be expected from the disciple of the Abbé Marie, when he was named professor of mathematics at the military school of Paris. Here, from 1775 to 1780, he continued to give lessons on the scientific grounds of the military art to that ardent and intelligent body of youths from which have sprung not a few of our warlike celebrities, and whose number would have been more considerable, had not circumstances forced a part of them into emigration. It may be inferred that the instruction given by the young professor embraced the first elements of *balistics*, the art, namely, of throwing projectiles, and that he studied the learned treatises which Bezout, Borda, and other eminent men had published on these difficult problems; for when the Royal Academy of Sciences and Belles-lettres of Prussia proposed, for the prize of 1782, the question of *determining the curve described by balls and shells, regard being had to the resistance of the air, and giving the rules for ascertaining the range which corresponds to different initial velocities and to different angles of projection*, M. Legendre was quite in readiness to enter into the competition. His memoir, prepared on this occasion, was crowned with success in the public meeting of June 6, 1782, and was published at Berlin under the title of *Recherches sur la trajectoire des projectiles dans les milieux résistants*.*

Newton, it is stated in this memoir, was the first who made researches respecting trajectories in resisting mediums. He particularly considers that which takes place on the hypothesis of a resistance proportional to the simple velocity; but he gives merely approximations, and those but rough ones, for the trajectory which results when the resistance is proportional to the square of the velocity. The honor of the discovery is due to Jean Bernoulli, who published a general solution of the problem, supposing the resistance to be as any power whatever of the velocity. Long after, Euler discussed the same question in the Memoirs of the Academy of Berlin for the year 1753. His object was to apply the theory to balistics, and for that he proposes very ingenious means. In the memoirs of the same Academy for the year 1765, and elsewhere, we find very extended researches by Lambert with the same object. Borda, in the Memoirs of the Academy of Sciences of Paris for the year 1769, has treated this question with his usual elegance and ingenuity. Conformably with the idea of Newton, he substitutes for the true trajectory that which would be described in virtue of a density but slightly variable, and he obtains by this means an approximation much superior to that of Newton. Lastly, Berout, in his Course of Artillery, published in 1772, made a more particular application of methods of his own to the trajectory of shells and bullets.

* This memoir bore for its motto: *Tolluntur in altum ut casu graviore ruant.*

M. Legendre propounds the equation of the movement of the projectile on the supposition that the resistance of the air is proportional to the square of the velocity. He integrates this equation with elegance, and the reduction into series forms more especially the remarkable part of the memoir. Although the hypotheses which he advances on the variation of the density of the air have been modified, his calculations have remained the type of those that have been made more in detail on the supposition of a resistance proportional to the square of the velocity. M. Français, professor at the schools of artillery, and General Didion have only supplied improvements to his method.* But this solution of the balistic question is simply a monument, so to speak, in the history of the science, since the necessity has been recognized of introducing, in the expression of the resistance of the air, a term proportional to the cube of the velocity. It is not the less certain, however, that by his memoir Legendre, young as he yet was, has earned for himself a distinguished place in the series of mathematicians to whom is due the superiority of the European artillery; a series which commences with Newton, in which M. Poisson occupies an eminent rank, and which is continued with so much éclat by the learned officers to whom we owe the actual precision of our artillery and the employment of rifled cannon.

But, however seductive this first success might appear, M. Legendre did not continue to occupy himself with the application of science to military art, and we read at this early stage on the title page of the Dissertation on Balistics, printed in 1782, the announcement that it is "by A. M. Legendre, *late* professor of mathematics in the military school at Paris." The youthful veteran, to whom perhaps the military discipline had never been particularly congenial, had decided to reserve his whole time for the study of departments of mathematics which, while not more difficult, pertain to an order of ideas generally considered as more elevated.

He had been occupied for some time with researches on the mutual attractions and forms of the planetary spheroids, and read at the Academy of Sciences of Paris, January 22, 1783, a memoir on the attraction of spheroids, for the examination of which, MM. d'Alembert and de Laplace were named commissioners. It was at this same sitting, as we learn from the invaluable journals of the Academy, that MM. Daubenton and Bezout made a favorable report on a memoir of the Abbé Haüy, relative to the structure of fluor spars; for it was the epoch when M. Haüy was submitting to the Academy, in a series of memoirs, the ideas which have become the basis of crystallography.

M. Legendre finished the reading of his memoir in the sitting of the 19th of February, and in that of the 15th of March, MM. d'Alembert, Bezout and de Laplace read the following report:

> The Academy having charged us with the examination of two memoirs of M. Legendre on the attraction of spheroids, we proceed to render an account of them. Geometers well know the admirable synthetic theory of M. Maclaurin on the attractions of spheroids, of which all the sections are elliptical, &c., &c. M. de Lagrange subsequently arrived at the same results by analogy alone in the Memoirs of Berlin for 1771, but all these researches suppose the point attracted at the surface, or in the interior of the spheroids. * * * *

I regret the impossibility of reading the whole of this report, written with a masterly hand and inimitable clearness by M. de Laplace, who had himself the year before communicated to the Academy a learned theory of the attractions of spheroids and of the figure of planets,† a circumstance which renders still more honorable, both for himself and M. Legendre, the justice which he so cheerfully and explicitly accords to his competitor, as yet almost unknown. I will content myself with saying that after having analyzed the two memoirs of M. Legendre, who arrives at the conclusion that, in order to determine the

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* See *Traité de balistique*, by General Didion, second edition, revised and enlarged, 1860; pp. 246–251.

† *Mémoires de l'Académie royale des Sciences* for the year 1782.

attraction of a spheroid on any exterior point, it suffices to cause the surface of another spheroid described from the same foci as the first to pass by that point, the illustrious reporter closed his remarks as follows:

The theorem which forms the principal object of these two memoirs is highly interesting. It is a new step taken in the theory of attractions of spheroids: the analysis is very able, is presented moreover with much elegance and clearness, and announces in its author distinguished talent. We think, therefore, that these memoirs merit the approbation of the Academy, and should be printed in the Collection of foreign savants.

After the conclusions drawn in their report, which were adopted by the Academy, the commissioners further added:

Besides the two memoirs of which we have just rendered an account, M. Legendre has presented to the Academy at different times memoirs on the resolution of intermediate equations of the second degree, and on the properties of continual fractions; on several problems of probabilities; on the summation of continual fractions, and on the rotation of bodies, which are not quickened by any accelerative force. All these memoirs have been esteemed worthy of being printed among those of foreign savants. Finally, M. Legendre has borne off the prize last proposed by the Academy of Berlin on balistics, or the movement of projectiles.

Thus the reporters made incidentally a complete statement of the academic titles of M. Legendre, nor was this done without intention, for there was an election at hand in the class of mechanics. The journals inform us in effect that, at the following session of the 19th March, (the Academy then met twice a week,) MM. Coulomb, Bossut, Le Roy, and Cousin also made a report on two memoirs of M. Périer; the first containing a description of a steam-pump, which the latter had just constructed at Chaillot to raise the waters of the Seine, upon the principles of MM. Watt and Bolton; and the second in relation to another pump, which the same engineer had erected at that place, after ideas of his own. These works, with which every one is now familiar, appeared to the Parisian population of that day a marvel of a wholly novel kind. The learned reporters concluded by saying:

We think that the two memoirs of which we render an account, in which the author describes in a simple and lucid manner a steam mechanism of his own invention, as well as that of MM. Watt and Bolton, deserve the approbation of the Academy, and should be included in the Collection of foreign savants.

At this sitting the Academy likewise received a favorable report from MM. Desmarest, Tillet, Coulomb, and Monge on a memoir of M. Duhamel, correspondent of the Academy and inspector general of mines, relative to a new instrument for determining the intersection of lodes. The journal goes on to inform us that at this same sitting the members of the class of mechanics presented MM. Legendre, Meunier, Périer, Duhamel, and Defer; that the first voices were for M. Legendre, and the second for M. Périer. It was the manner of expressing at that time the votes of the Academy, which was composed of four kinds of members: honoraries, of whom few were present at the sittings; pensionaries, associates, and adjuncts, to whom were sometimes added supernumerary adjuncts. Among the names of academicians who took part in the scrutiny of the 19th of March, 1783, we remark those of MM. Cassinide Thury, d'Alembert, Lavoisier, Lalande, Daubenton, Borda, Bezout, the Marquis Condorcet, Bailly, Rochon, Monge, Berthollet, de Jussieu, Tessier, and several other celebrated savants, a part of whom will be remembered by some who hear me, as having, at a later period, occupied with themselves the benches of the Institute.

In the sitting of the 2d April, the perpetual secretary (Condorcet) read the following letter of M. Amelot, dated from Versailles, 30th March, 1783:

I have the honor of informing you that the King has nominated M. Legendre to the place of adjunct of the Academy of Sciences, vacant in the class of mechanics by the nomination of M. de Laplace to a place of associate, and that his Majesty has also thought proper to name M. Périer to a place of supernumerary adjunct in the same class.

I have supposed that, in reverting to the first brilliant successes of M. Legendre, it would perhaps be agreeable to my auditors to carry back their thoughts for a

moment to the constitution and usages of the ancient Academy of Sciences of Paris, from which our own differ in some respects, though on many points they have remained identically the same.

I hasten to return to the labors of M. Legendre, which followed one another at short intervals. He read to the Academy, July 4, 1784, *Researches on the figure of planets*, in which he again discussed in a felicitous manner a subject treated by M. de Laplace. It had been ascertained by illustrious geometers that when a planet, supposed to be fluid and homogeneous, revolves upon itself, it arrives definitively at an ellipsoidal figure, slightly flattened at the two poles of rotation, and that among the figures which may be attributed to the meridian curve, the ellipsis is one of those which satisfy the condition of equilibrium; but no one had yet discovered that the ellipsis is the only curve which can satisfy the condition. M. de Laplace, in his memoir of 1772, had said positively that he would not venture to assert that this figure was the only one which could do so; that it would be first necessary to know in finite terms the complete integral of the differential equation of the problem, and that he had not yet been able to obtain it. This M. Legendre accomplished by availing himself of the ingenious analysis of his memoir on the attraction of the spheroids, and he concludes that if a planet in equilibrium be supposed to have the figure of a solid of revolution little different from a sphere, and divided into two equal parts by its equator, the meridian of that planet will necessarily be elliptical.

"The proposition which forms the object of this memoir," he observes in a note, "having been demonstrated in a much more skilful and general manner in a memoir which M. de Laplace has already published in the volume of 1782, (printed later than its date,) I should draw attention to the fact that the date of my own memoir is earlier, and that the proposition which appears here, as it was read in June and July, 1784, gave occasion to M. de Laplace to investigate the subject thoroughly, and to present to geometers a complete theory thereof."

Other great geometers also have added their discoveries to those of M. Legendre,* but nothing has effaced the merit of his two memoirs drawn up in 1782. Hence, M. Poisson, in the learned and eloquent discourse which he pronounced January 10, 1833, at the grave of Legendre, took occasion to say:

> The reduction into series of which he made use in the first memoir, gave rise to theorems which have been since extended, but which are still the basis of the theory at which we have subsequently arrived. In the second, he gave the only direct solution yet known of the problem of the figure of a homogeneous planet, supposed to be fluid, and soon afterwards he extended his researches to the general case of a planet, composed of heterogeneous strata.†

In the course of his memoir, M. Legendre finds that the terrestrial spheroid, which is in equilibrium when the axes are in the ratio of 230 to 231, may still be so if the axes be supposed in the ratio of 1 to 681, which affords quite a strange figure, but one which recalls the ring of Saturn. He adds that d'Alembert was the first to remark that there might be several elliptical spheroids which would comport with equilibrium. We see by these different examples what emulation existed between those fine intellects, d'Alembert, Lagrange, Laplace, Legendre; with what rapidity their labors succeeded, while they mutually completed one another. It may further be remarked that M. Legendre supposes only in an implicit manner that the spheroid is one of revolution. The equation found by him is that of the meridian curve, and his analysis is in no respect contradicted by the discovery, as curious as it was unexpected, made in our time almost simultaneously by M. Liouville and M. Jacobi, that the planetary ellipsoid may have its three axes unequal, and that the equator may itself be an ellipsis.

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* Since the death of M. Legendre, the question of the attraction of an ellipsoid on an external point has been completely resolved in an analytic manner by M. Poisson, (*Mémoires de l'Acad. des Sciences de l'Institute*, t. xiii, p. 497, 1835;) and in a synthetic manner by M. Chasles, (*Mémoires des savants étrangers à l'Academie des Sciences*, t. ix, p. 629, 1846.)

† Discourse pronounced at the funeral of M. Legendre, January 10, 1833, by M. Poisson.

M. Legendre subsequently resumed the questions treated in these first and memorable memoirs, particularly in 1790, in the sequel of his researches on the figure of the planets; in 1789, in a memoir on double integrals, in which he completes the analysis of his memoir on the attraction of spheroids; and still later, in a memoir read to the Academy in 1812. After having pointed out, in this last, the improvements contributed to his preceding labors on this subject by M. Biot, who had conceived the happy idea of applying thereto an integral given by M. de Lagrange for another object, M. Legendre avails himself of the substitution discovered by M. Ivory to present the entire theory of the attraction of homogeneous ellipsoids with all the simplicity of which it is susceptible.

But these important labors were far from entirely absorbing M. Legendre's attention, and the varied nature of the memoirs which he presented in great frequency to the Academy, to a mere enumeration of which I must here confine myself, evinced the extent of his knowledge and the surprising fecundity of his genius.

In 1785, he read to the Academy a masterly memoir entitled *Researches on indeterminate analysis*, which includes numerous propositions on the theory of numbers, and especially the celebrated *theorem of reciprocity* known under the name of the *law of Legendre*.* In 1786, a memoir on the manner of distinguishing *maxima* from *minima* in the calculation of variations.† Also, two memoirs on integrations by arcs of the ellipsis, and on the comparison of these arcs,‡ memoirs which contain the first rudiments of his *theory of elliptical functions*. In 1787, a memoir on the integration of certain equations with partial differences. By a simple change of variables, he arrives rigorously at the integral of an equation which Monge had only integrated by a process depending on certain metaphysical principles about which there still existed some doubts. By proving that the integral was exact, M. Legendre contributed to corroborate the reputation of the illustrious author of the application of analysis to geometry, whose name also is one of the characteristic glories of the French mathematical school. In this same memoir he gives by his method the integrals of several classes of equations with partial differences of superior orders; then, very happily extending an idea of Lagrange for the integration of non-linear equations of the first order, he distinguishes therein six cases of integrability which they may present. Again, in 1790 he read a memoir on the *particular integrals* of differential equations, of which he modestly says that the principle and demonstration are only consequences very easily to be deduced from the theory which M. de Lagrange had given in the Memoirs of the Academy of Berlin for 1774. He establishes that particular integrals are always comprised in a finite expression in which the number of arbitrary constants is less than in the complete integral, thus preparing the way for the definitive labors which M. Poisson has since made public on this subject.

But at this epoch M. Legendre was already engaged in another series of researches which occupied him at intervals for a great number of years, and in which his labors were fertile in important results.

In 1787, some doubts having been raised upon the respective position of the observatories of Paris and Greenwich, it was decided to connect the meridians by a chain of triangles which should extend from one point to the other. The Academy of Sciences confided to three of its members, MM. Cassini, Mechain, and Legendre, the execution of this operation, in concert with Major General Roy and several other English savants. These important labors were accordingly performed with all the exactness which the state of science then permitted—by the help of an excellent quadrant prepared by the celebrated English artist Ramsden, and the repeating circle constructed by Lenoir upon the principles of

* *Mém. de l'Academie des Sciences*, vol. for 1785.
† *Mém. de l'Academie des Sciences*, vol. for 1786, p. 7.
‡ *Mém. de l'Academie des Sciences*, for 1786, pp. 616–644.

Borda. M. Legendre calculated all the triangles situated in France, and afterwards those also which extended in England as far as Greenwich. On this occasion he went to London, where he was received with the distinction due to him, and was named member of the Royal Society of London. He published at this time in the Memoirs of the Academy for the year 1787 (printed in 1789) an important paper entitled, *Memoir on the trigonometrical operations of which the results depend on the figure of the earth;** of this he has himself explained the object in terms which I take the liberty of abridging:

The only question here is that which regards operations exacting extreme precision, such as the measurement of the degrees of the meridian or of a parallel, and the geographical determination of the principal points of a large area from the triangles which connect them. Operations of this kind may be carried henceforward to a great degree of precision by means of the repeating circle. In effect, the use which we have made of this instrument, in 1787, has convinced us that it can give each angle of a triangle to about two seconds, or even more exactly, if all circumstances are favorable. It is further necessary that the calculations established on such data should not be inferior to the latter in exactness; especially is it requisite to take account of the reduction to the horizon, which amounts quite often to several seconds; and thence arise triangles of infinitely small curvature, the calculation of which demands special rules; for, by considering them as rectilinear, we should neglect the small excess of the sum of the three angles over 180°, and by considering them as spherical, the sides would be changed into very small arcs, the calculation of which by the common tables would be neither exact nor commodious.

I have assembled in this memoir, continues M. Legendre, the necessary formulas, as well for the reduction and calculation of these sorts of triangles, as for what relates to the position of the different points of a chain of triangles on the surface of the spheroid. In these calculations, he adds, there are some elements susceptible of a slight uncertainty. * * * * In order that the calculation need be made but once, and to judge by a glance of the influence of errors, I have supposed the value of each principal element to be augmented by an indeterminate quantity which denotes the correction of it. These literal quantities, which are to be regarded as very small, do not prevent the calculation from being proceeded with by logarithms in the usual manner.

This was an important addition to the methods of calculation employed till then, and still later he further added the *method of least squares.* He gives in this memoir formulas for the reduction of an angle to the horizon, as also for other determinations, and especially the important theorem known under the name of the *theorem of Legendre*, through which the calculation of a spherical triangle of small extent is reduced to that of a rectilinear triangle, by subtracting from each of the three angles the third of the spherical excess of their sum, that is to say the inconsiderable quantity by which this exceeds 180°. M. Legendre has subsequently demonstrated that this fundamental theorem is applicable also to spheroidal triangles, whether traced on an ellipsoid of revolution or even on a spheroid slightly irregular.

He also occupies himself, in the same memoir, with the value of the degrees of the meridian in the elliptical spheroid, and with the determination of the respective position of different places deduced from the nature of the shortest line which can be traced on the surface of this spheroid from one extremity to the other of the chain of triangles and from the intersections of that line with the different sides of the triangles or with their prolongations. This line, which M. Legendre, at different times and always with success, made the object of his researches, bears the name of the *geodesic line;* on the regular ellipsoid it is of double curvature, unless it coincides with a meridian. Finally, he occupies him-

**Mém. de l'Academie des Sciences,* for 1787, (printed in 1789,) p. 352.

self with the operations which have for their object the measurement of the degrees of the meridian, and concludes with some theoretical and practical reflections on the use of the repeating circle of Borda in the delicate operations which relate to that object.

These reflections were judicious; but at the moment of recording them, M. Legendre, struck with the progress which the construction of instruments had recently made, did not foresee those improvements which it was even then on the point of receiving. They were such that at the end of 30 years the operations of 1787 were found to be inferior in the measurement of angles and bases, the observation of night-signals, &c., to those generally executed in this way. Hence it resulted that the geodesic connection of Dunkirk and Greenwich required to be recommenced in 1817. This new undertaking was confided to MM. Arago and Mathieu, associated with Captain Kater and other English savants. What remained and will always remain of the operations of 1787 are the formulas and theorems which it furnished M. Legendre the occasion of establishing, and which in the sequel he still further developed and improved.

His memoir was written in the anticipation of new and more extended applications; for the project already existed of resuming the measurement of the meridian which traverses France from north to south, and which had been once measured, in 1739 and 1740, in the great and admirable geodesic operation which had supplied the basis of the chart of Cassini. The National Assembly, in effect, having adopted the plan of establishing a new system of weights and measures for all France, a report was made to the Academy of Sciences, March 19, 1791, by MM. Borda, Lagrange, Laplace, Monge, and Condorcet, on the choice of a unit of measure. The report, after a profound discussion of the subject, proposed to take as the unit of measure the *metre*, representing the ten-millionth part of a quarter of the meridian, calculated from the measured length of the arc comprised between Dunkirk and Barcelona. It proposed at the same time the execution of different preliminary operations, one of the most important of which was the verification, by new observations, of the series of triangles employed for the measurement of the meridian of Cassini and its prolongation to Barcelona.

It was afterwards agreed that MM. Cassini, Mechain, and Legendre, the same who had connected the meridian of Paris with that of Greenwich, should be charged with this new operation. Yet M. Legendre is not comprised in the number of the 12 commissioners nominated (April 17, 1795) to conduct all the labors necessary for fixing the bases of the metrical system. These commissioners designated from their own number MM. Mechain and Delambre to execute the measurement of the angles, the astronomical observations, and the measurement of the dependent bases of the meridian, and it was they in effect who, in very difficult times, had the merit of executing this vast operation with means often greatly restricted; yet, a few years afterwards, we find M. Legendre among the members of the mixed commission, formed of a union of French and foreign savants, to which the duty of examining and verifying the whole work was entrusted. All the triangles were separately calculated by four persons, MM. Trallés, Van Swinden, Legendre, and Delambre, each employing the method he preferred, and the results were only admitted when there was a satisfactory agreement between the four calculations. M. Legendre signed with the other commissioners the report made to the National Institute, June 17, 1799, on the basis of the metrical system, and he continued to take part in all the ulterior calculations and the different verifications rendered necessary by certain discordances which had been remarked, and by some doubts which had arisen on the exactness of several parts of the operation. The method he followed was that of which he had established the basis in his memoir of 1787. In applying it on so extensive a scale, he improved and developed it, and gave a large number of new theorems leading to more rapid reductions, to more convenient formulas. He read

to the first class of the Institute, March 3, 1806, a new memoir entitled, *Analysis of triangles traced on the surface of a spheroid*, in which he considers the triangles as no longer described on the sphere, but on a spheroid. He inquires and demonstrates the properties of the shortest lines traced on its surface; extends and thus generalizes the numerous applications of the theorem which bears his name, and reviewing the principal operations offered by geodesy, gives the most complete analysis of them.

He concludes that there can remain no doubt of the exactness of the calculation of the triangles from which the distance of the parallels between Dunkirk and Montjouy, near Barcelona, has been computed, as well as the length of the metre; but he considers it beyond question that the results deduced from different chains of triangles do not always exactly accord among themselves, on account of certain anomalies in the latitudes and azimuths which may be due to local attractions.

At this epoch, in 1805, M. Legendre had just published, in the sequel of his new methods for the determination of the orbits of comets, an appendix on the *method of least squares*. Here he proposed that method which has generally been adopted for deriving from the measures yielded by observation the most exact results which they are susceptible of furnishing. M. de Laplace has since demonstrated that it is the most advantageous of which we can make use in practice. M. Legendre, after having developed it, made an immediate application of it to the measurement of the degrees of the meridian of France, and he concluded, as in the geodesic memoir, that the anomalies in the latitudes ought not to be attributed to the observations, and that they pertain probably to local attractions which act irregularly on the plumb-line. M. Gauss, in 1809, seems to have thought, for the moment, that he had rights of priority to the invention of the *method of least squares*;* but, if it cannot be contested that so eminent a savant may have had the same idea with M. Legendre, and may even have applied it in his labors, it is certain that M. Legendre had, on his part, discovered the method and was the first who published it.

M. Legendre continued henceforth to make part of the commission of weights and measures; but, though his labors of 1787 had rendered his co-operation indispensable in the great enterprise which that commission was charged with conducting to a successful issue, there was a period during which, as we have said, he ceased to be officially attached to it: this was under the reign of terror. Like most of the savants of his epoch, he was favorable to the ideas which have become the basis of modern society; but he remained a stranger to the excesses which imbrued the Revolution in blood. Perhaps, indeed, his caustic turn had not wholly spared its authors; certain it is, that, during the violence of the storm, he was forced to hide himself. It was one of the most happy incidents of his life; for, in the retreat which he found in Paris itself, he formed the acquaintance of a young and engaging female, *Marguerite-Claudine Couhin*, whom he espoused shortly afterwards, and who constituted his happiness during 40 years. Much younger than her husband, she bore no inefficient part in his great labors by the tranquillity, the assiduous attentions, the watchful solicitude, with which she environed him, proving herself, in all circumstances, a model of discretion, grace, and amiability.

The revolutionary turbulence, however, had itself never interrupted the labors of M. Legendre. In the year II of the republic, towards the end of 1793, he published a new memoir on *elliptical transcendents*, forming a quarto

* In his work, entitled *Theoria motus corporum celestium*, M. Gauss expresses himself with respect to this in the following manner: "This principle, which we have employed since the year 1795, has been lately given by M. Legendre in his *Nouvelles Méthodes pour la determination des orbites des comètes:* Paris, 1806. There will be found in that work several consequences which the desire of being brief induces us to omit." (See the work entitled *Méthodes des moindres carrés*, *Mémoires sur la combination des observations*, by M. Ch. F. Gauss, translated into French and published with authority of the author by M. J. Bertrand, 1855, p. 133.)

volume of more than 100 pages; but in the quietude of his happy retreat he had turned his thoughts to other subjects. The former professor of mathematics in the military school began anew to occupy himself with the *Elements of Geometry*. The first edition of his work under this title, a work written with elegant simplicity, and in which all the propositions are disposed in a natural and methodical order, appeared in 1794. The author, modelling himself upon Euclid, remands the science to the severity of the Greek school. In this, without perhaps designing it, he accommodated himself to the spirit of his epoch. Architecture, abandoning the distorted forms of the reign of Louis XV, was returning, more and more, to the elegant simplicity of the Greek style. A few years previous our great painter, David, had inaugurated, by his picture of the *Horatii*, a complete revolution in painting, which, after his example, reverted likewise to the imitation of the ancients.

The work attained at once the first rank among classical books. In less than 30 years fourteen editions were published, of which the last has undergone a large number of impressions: more than 100,000 copies of it have been sold in France alone. Legendre's *Elements of Geometry* have been reproduced in the principal languages of Europe, and have been even translated into Arabic for the schools established in Egypt by the viceroy, Mehémet-Ali.

The author, prepossessed with the method of Euclid, has perhaps somewhat unduly availed himself of the *reductio ad absurdum*, which might often be replaced by more facile demonstrations; but his work has served to excite a sort of vigorous intellectual gymnastics by which mathematical studies have been invigorated, and its influence has been undoubtedly salutary. Among other things, M. Legendre here demonstrates, in a novel manner, the equality of volume of two symmetrical polyhedrons formed of equal plane faces, adjusted under the same angles, but with an inverse arrangement which does not admit of their being superposed. The first editions did not contain the excellent treatise on trigonometry which the author has added to subsequent ones. He has also enriched these with notes, in which he treats analytically certain parts of geometry on a new system, as where he demonstrates that the ratios of the circumference to the diameter and to its square are irrational numbers.

The ratio of the circumference to the diameter, being an irrational number, is not susceptible of being exactly expressed by any fraction, however great the whole numbers which form the numerator and denominator. Hence results the *impossibility* of ever finding the quadrature of the circle, and it was in consequence of a proposition of M. Legendre, based on this demonstrated impossibility, that the Academy renounced all further attention to a problem, the importance of which is in some sort axiomatic among persons little versed in mathematics.

But whatever might be the success of his *Elements*, M. Legendre did not question the feasibility of using other methods with success, and himself contributed, in 1802, to the publication of a new edition of Clairaut's *Elements of Geometry*, to which he added notes derived probably from his memoranda of the military school. Geometry is further indebted to him for a method, directly demonstrated by himself, of inscribing in the circle a regular polygon of 17 sides. Algebra, properly so called, owes to him, among other things, two different methods for the solution of numerical equations, methods which make known with much rapidity all the roots, whether real or imaginary, of those equations.

So highly was M. Legendre appreciated as a skillful calculator, that rarely was any great series of numerical operations undertaken in France without recourse being had to his services. In 1787 he had been called to take part in the commission charged with connecting trigonometrically Dunkirk and Greenwich. For the same reason M. de Prony, placed in the year II (1794) at the head of the *cadastre*, (registry of the survey of lands,) did not deem it expedient to dispense with his services. The decimal division of the circle, then regarded as a neces-

sary complement of the metrical system, required new trigonometrical tables. M. de Prony caused them to be constructed, with incredible celerity, by means of the division of labor and by processes wholly new, which admitted of the employment of arithmeticians of even the most indifferent qualifications. The work was prepared by a section of analysts, over which presided M. Legendre, who contributed greatly to facilitate the operation by devising new and ingenious formulas for determining the successive differences of the sinus. For the other sections it only remained to make the additions. The labors of this board of calculation produced two copies of tables entirely independent one of the other, and affording, by their identity, a mutual verification. This monument of labor and skill, the most vast of its kind which has ever been executed or even conceived, has no other defect, said M. Delambre, but its *very immensity*, which has so long delayed its publication.

When the revolutionary tempest had begun to subside, one of the first cares of government was to reorganize public instruction; but M. Legendre, whether he was not in favor with the men in power or for whatever other reason, was not invited to co-operate. His name does not either figure at the close of 1794 among those of the first professors of the Polytechnic school, nor in January, 1795, in the list of the professors of the Normal schools; nor yet was he comprised among the 48 savants whom the government selected to form the nucleus of the Institute; but, at the earliest opportunity, his colleagues hastened to redress this injustice by summoning him to their ranks. It will not be amiss to recall here the succession of events, as facts not destitute of historical interest.

The Academy of Sciences having been suppressed by a decree of the convention of the 8th of August, 1793, the National Institute, of which the first class represented that academy, was established by a law of the 5 fructidor, year III, (22d August, 1795,) and was organized by a second law of the 3 brumaire, year IV, (25th October, 1795.) By the ninth article of this law it was enacted that, "for the formation of the National Institute, the Executive Directory shall nominate 48 members, who shall elect 96 others." To form the nucleus of the first class of the Institute, 20 members were accordingly nominated by the directory, December 6, 1795, being two for each section; those for the section of mathematics were MM. Lagrange and Laplace. Two other members, MM. Borda and Bossut, were elected in the meeting of the 9th of December, and the section, which was to be composed of six members, was completed on the 13th of the same month by the election of MM. Legendre and Delambre. In this list M. Bossut appeared by just title for his labors in hydraulics; MM. Borda and Delambre were included with not less right for their important services in relation to geodesy, to measures of precision and astronomical calculations; MM. Lagrange, Laplace and Legendre were essentially the representatives of the higher analysis, and occupied during life the foremost place among the geometers of the Institute. All three continued till death to justify this proud position by labors worthy of themselves and of the illustrious body to which it was their pleasure as well as duty to communicate them.

In 1805 M. Legendre published new methods for the determination of the orbits of comets, to which he added, in 1806 and 1820, two supplements; in the latter stages of life he had collected the most recent observations on comets of short periods, in the design of still further applying and improving his processes of calculation. Previous to the publication of his two first memoirs in 1805 and 1806, the question had, in his opinion, been always treated in an imperfect manner and merely by approximations. He considered himself as having first indicated two certain modes of arriving at a solution, at once the most simple and exact, namely, *the method of indeterminate corrections*, proposed by him as early as 1787, but the applications of which had been few in number, and the *method of least squares*, which then appeared for the first time. Nevertheless, this analytic perfection, to which the author sought to add as often as he retouched his formulas, has seemed to astronomers to be more than coun-

terbalanced by the length of the calculations and by other inconveniences. They prefer employing the methods of Olbers and Gauss, which, while giving perhaps a less certain approximation, furnish it in all cases more rapidly. In 1806 M. Legendre further published, in the memoirs of the Institute, a new formula for reducing to true distances the apparent distances from the moon to the sun or to a star.* Its object was to simplify and accelerate the labors of practical astronomers.

These last publications were in some sort excursions made by the indefatigable author beyond the habitual sphere of his researches, and, seeing with what promptness and facility M. Legendre thus passed from one subject to another, it might be thought that he was completely at liberty in the employment of his time. He found means, however, in the midst of his purely scientific labors, to reconcile with the duties of the academician those of several important functions.

Some time after the creation of the Polytechnic School, the former laureate of the balistic competition was appointed examiner in mathematics for the graduating students destined for the artillery, and he continued to fulfil these honorable and delicate functions till 1815, when he voluntarily withdrew and was replaced by M. de Prony. From the creation of the university, in 1808, M. Legendre was of its council. At the death of Lagrange, in 1812, he was chosen to succeed him at the bureau of longitudes, in quality of geometer. He thus took his place by the side of M. de Laplace, whom he had replaced in 1783, as adjunct member of the Academy of Sciences, when the illustrious author of the *Méchanique Céleste* became an associate member. Thus, at an interval of 29 years, and under circumstances assuredly very different, no one was found in France who, by his scientific merit, could more naturally be called than M. Legendre to replace M. de Laplace or M. de Lagrange. That he owed to his merit alone a choice so honorable for himself and those who made it, may be gathered from a slight anecdote which is related of him. Having, from the creation of the legion of honor, been inscribed in the number of its chevaliers, though he failed not to record this testimony to his merit in the title-page of his works, his natural modesty, we are told, long prevented him from attaching the red riband to his button-hole. M. Legendre continued, moreover, as has been already said, to form part of the commission of weights and measures as long as it existed, and more than once was a member of other commissions charged with objects of importance.

Yet independently of these numerous occupations and varied labors, all impressed with a peculiar character of vigor and precision, by which he bore a large part in the scientific movement of his epoch, M. Legendre had besides certain *household gods*, to which he sacrificed with ever renewed pleasure in the silence of his closet. I mean the *theory of numbers* and the *elliptical functions*. To these he consecrated, during the latter 50 years of his life, all the leisure left him by his daily occupations and more conspicuous labors. He has thus reared two monuments which, by their extent, represent, no doubt, the better part of his time, and which, though having had few readers and capable of having but very few judges, will prove, perhaps, in the eye of posterity, two of his principal titles to renown.

The *Theory of numbers* appeared in 1830, in two quarto volumes, after being preceded at divers intervals by preliminary publications. M. Legendre says, in the advertisement:

> The work having received all the improvements which the author has been able to bestow upon it, as well through his own labors as those of other geometers of which he could avail himself, it has been thought proper to give it definitively the title of *Theory of numbers*, in place of that of an *Essay* on the subject which it has heretofore borne.

The *Essay on the theory of numbers* had passed through two editions, one in 1798, the other in 1808; this last had been followed by two supplements. The

**Mémoires, de l'Institute*, t. VI, (printed January, 1806,) p. 30.

Essay had itself been preceded by a considerable work published in the Memoirs of the Academy for 1785, and entitled *Recherches d'analyse indéterminée ;* which relates principally to the study of the properties of numbers. In fine, we learn from the manuscript proceedings of the Academy, before cited, that, among the memoirs which M. de Laplace, in the session of March 15, 1783, indicated as having been presented by M. Legendre, occur two memoirs on the resolution of indeterminate equations of the second degree and on the properties of continual fractions, and a memoir on the summation of these fractions. Now, from the objects of which they treat, and indeed from the titles alone, these memoirs bear a very natural relation to certain paragraphs of the great memoir of 1785. They were probably the first rudiments of it. Hence we see that M. Legendre had been occupied with the theory of numbers from his youth. He had labored upon it for more than 50 years. Yet he concludes the advertisement of the *Theory of numbers*, dated April 1, 1830, with the following words, which are certainly modest enough :

We shall not pretend that certain matters treated of in this work do not need to be improved or even rectified by new researches. Nevertheless, the author has thought that it would be better to leave them in this state of imperfection than to suppress them altogether ; they will offer a subject of investigation to those who may be disposed in the future to occupy themselves with the advancement of the science.

This part of the science has received in effect, since the publication of the *Theory of numbers*, important accessions ; but if we compare the contents of this learned work with what had been discovered during the 2,000 years which preceded 1785, we shall see that no savant has marked his passage in this branch of mathematics by traces in any degree comparable to these efforts of M. Legendre. It cannot surprise us that a science which had advanced with but slow and progressive steps under the hands of men as eminent as Euclid and Diophantes among the ancients, as Viète, Bachet, Fermat, Euler, and Lagrange among the moderns, should not all at once have been carried to a point which comported with no further progress. It behooves us, on the contrary, candidly to avow that M. Legendre, in speaking of new developments which still awaited it, gave proof of perspicuity almost as much as of modesty.

The science of numbers is difficult, and it is above all difficult to convey an idea of it to persons whose attention has never been occupied with it. Every one knows that numbers are distinguished into two great classes: even and odd numbers, which alternately succeed one another. The even numbers are divisible by 2, while the odd numbers are not, though they have often other divisors. Whole numbers differ much from one another in the possibility of being divided by other and smaller integers. It has been long ago remarked that the number 10, the basis of our decimal system, has but two divisors, 2 and 5, the last of which is not subdivisible, while the number 8 has two divisors, 2 and 4, of which the last is further subdivisible by 2, and the number 12 has three divisors, 2, 3, and 4, the last of which is again subdivisible by 2; whence it follows that the number 8 and especially the number 12 have, as the basis of a system of measures susceptible of being successively subdivided, an incontestable superiority over the number 10. This inferiority of the latter number is one of the obstacles to the general adoption of the decimal system of weights and measures, which presents in other respects such great advantages.

But the number 10 is more favored in this regard than the number 9, divisible only by 3, of which it is the square. It is still more so than the numbers 3, 5, 7, 11, 13, 17, which have no divisors, or, to speak the language of science, have no other divisors but themselves and unity. Number 7, which enumerates the seven days of the week, the seven wonders of the world, the seven sages of Greece, passes for possessing a certain degree of excellence ; but number 13, as well as 17, is looked upon as inauspicious, by reason, it may be, of this absence of divisors which renders both numbers refractory. All those numbers which have no other divisors but themselves and unity, are called *prime numbers*.

There are prime numbers of all magnitudes; but when the numbers are somewhat great it is not easy to discover immediately whether they are prime or not. The prime numbers are distributed among the odd numbers with an apparent irregularity which is yet subject to certain laws. The search for them, the determination of the quantities of them which exist in a given interval of the numeric scale, form one of the objects of the theory of numbers.

Numbers may be ranged by series in each of which may be remarked the constant existence of certain properties; such are the triangular numbers 1, 3, 6, 10, 15, &c., each expressing a number of units which may be arranged triangularly; the quadratic numbers 1, 4, 9, 16, 25, which in the same way correspond to the square; polygonal numbers, pyramidal, &c.; and these series give rise to combinations more or less curious. Certain numbers are the squares of other smaller ones, as 4 the square of 2, 9 of 3, &c.; others, as 8, 13, 18, are the sum of two squares; others again, like 17 for example, are the sum of three squares. Lagrange and Euler have proved that *there is no number which is not the sum of four or of a less number of squares.**

These properties and many others are at once remarked in examples taken among numbers of little amount, and it becomes a matter of curiosity to follow them among the larger numbers in order to learn whether they are general or not. Hence proceed researches which are often very difficult and provoke a lively interest. The final conclusion evades detection so much the longer from the circumstance that frequently there exists, as yet, in science no rule for seeking it; it is a prey which for a long time eludes the pursuit of the hunter. Again, there are certain properties of numbers which come to light unexpectedly in their combinations, and which, presenting something enigmatical and surprising, have been often held to pertain to the mysterious. Hence the virtues which necromancers have pretended that they detected in cabalistic numbers; virtues which are to the theory of numbers not unlike what astrology is to astronomy.

"It would seem (remarks M. Legendre) that Euler had a peculiar taste for the science of numbers, and that he gave himself up to this kind of research with a sort of passion, as happens (he adds) to almost all those who are occupied with it;" and it is clear that M. Legendre himself formed no exception to this remark.

The first researches of M. Legendre on numbers, contained in his distinguished memoir of 1785, constituted a direct sequel to those of Euler and Lagrange which they extended and developed in several important particulars; but M. Legendre embodied also in this work many discoveries entirely new, and particularly the *theorem of reciprocity*, known likewise under the name of the *law of Legendre*, one of the most fertile laws of the theory of numbers.

This theorem, more readily expressed in algebraic than ordinary language,†

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* Legendre, *Theorie des Nombres*, t. I, p. 211.

† The following are the terms in which M. Legendre enunciates, in the *Theorie des Nombres*, I, 230, the theorem in question: § VI. *Theorem containing a law of reciprocity which exists between any two prime numbers whatever.* (166.) We have seen (No. 135) that if m and n be any two prime numbers, odd and unequal, the abridged expressions $\left(\frac{m}{n},\right)$ $\left(\frac{n}{m}\right)$ represent, one the remainder $m^{\frac{n-1}{2}}$, the other the remainder $n^{\frac{m-1}{2}}$ divided by m. At the same time it has been proved that one and the other remainder can never be other than $+1$ and -1. This being so, there exists such a relation between the two remainders $\left(\frac{m}{n}\right)$ and $\left(\frac{n}{m},\right)$ that one being known, the other is immediately determined. The following is the general theorem which contains this relation:

Whatever be the prime numbers m and n, if they are not both of the form $4x+3$, we shall always have $\left(\frac{n}{m}\right)=\left(\frac{m}{n},\right)$ and if they are both of the form $4x+3$, we shall have $\left(\frac{n}{m}\right)=-\left(\frac{m}{n}.\right)$ These two cases are comprised in the formula

$$\left(\frac{n}{m}\right)=\left(-1\right)^{\frac{m-1}{2}\cdot\frac{n-1}{2}}\cdot\left(\frac{m}{n}.\right)$$

consists in this: two prime numbers m and n being given, if m be raised to the power n minus 1 divided by 2 and the result be divided by n, then n to the power m minus 1 divided by 2, and the result be divided by m, the remainders of the two divisions, which are always capable of being expressed by plus 1 or minus 1, will both be of the same sign, or else of the contrary sign, in certain determinate cases; a result which has found and continues to find numerous applications in researches relating to the properties of numbers.

M. Legendre, in reproducing, in successive editions of the Theory of Numbers, the demonstration of this theorem as he had given it in 1785, discovered that in a determinate case it presents a lacuna, without the theorem itself having been ever found in default. M. Gauss, who, by his *Disquisitiones Arithmeticæ,* published in 1801, had placed himself in the first rank of the savants who have dealt with the theory of numbers, gave a demonstration of the theorem of reciprocity which left nothing further to be desired. M. Legendre reproduced this demonstration in his Theory of Numbers in 1830, observing that it is the more remarkable as resting on the most elementary principles, and at the same time gave another yet more simple, proposed by M. Jacobi. Still later, M. Lionville and other eminent geometers have given other demonstrations of the same law. The exactness of the *law of Legendre* is therefore more than sufficiently demonstrated; but here the inventor has left to those who have followed him the privilege of *completing* his discovery.

This circumstance recalls, somewhat remotely, the fate of the remarkable theorems on numbers which Fermat left without demonstration; all, with the exception of a single one, have been demonstrated within a century and a half after the death of their author, by Euler, Lagrange, and Legendre; this one, the last theorem of Fermat, without having ever been found in default, still awaits a demonstration, though the Academy has, in late years, several times proposed it as the subject of a prize to the emulation of geometers.

But if M. Legendre took delight, like Euler, in the combinations, so arduous in appearance, of the theory of numbers, like Euler, he excelled also in the research of the integrals of differential quantities, a research which is itself not directed by any certain rule, and in which the inquirer is conducted to the result only by a certain intuitive prevision of the combinations and reductions which will be available in the formulas and figures. The finest integrals appear often to have been found by hazard; but these are *hazards*, as M. Legendre said in speaking of Euler, *which never occur to any but those who know how to create them.* This remark, insufficient doubtless to make us comprehend how a differential expression is integrated, will enable us perhaps to conceive how the mind may be stimulated to this pursuit, as to that of the properties of numbers, and how these two kinds of research, which seem to call into play analogous faculties, were the two dominant passions of Euler and Legendre.

A differential quantity given by a problem of geometry, mechanics, or physics, does not always correspond to an analytic expression existing in the science, and, in order not to leave certain problems without solution, it becomes an object to enrich analysis with new functions. After having exhausted expressions purely algebraic, we succeed in integrating a great number of differentials by means of arcs of the circle and of logarithms which are the most simple of transcendent quantities; but, in order to extend still further the applications of the integral calculus, it was necessary to have recourse to transcendents of a more composite order.

Euler thought that instead of being limited to the circle, other curves of the second degree, especially the ellipsis and hyperbola, might be considered, and that tables analogous to the tables of logarithms and to those of circular functions might be drawn up in reference to them. By one of those happy combinations, which seem almost fortuitous, he found under a purely algebraic form the complete integral of a differential equation composed of two separate but similar

terms, each of which is only integrable by arcs of conic sections. This important discovery led the illustrious geometer to compare, in a manner more general than had been done before, not only the arcs of the same ellipsis or the same hyperbola, but in general all the transcendents of which the differential approximates to those of these two curves, in presenting, like them, a rational algebraic function of the variable divided by the square root of an algebraic polynome of the fourth degree.* One of the results of this comparison was, that the integration by arcs of the hyperbola may always be reduced to integration by arcs of the ellipsis.

From this time Euler foresaw that by means of a suitable notation the calculation of arcs of the ellipsis and other analogous transcendents might become of almost as general use as that of arcs of the circle and of logarithms; but, with the exception of the English geometer Landen, who demonstrated, in a memoir of 1775, that *every arc of the hyperbola is immediately rectified by means of two arcs of the ellipsis*,† no one but M. Legendre recognized the importance of realizing the prevision of Euler; and it may be said that our learned colleague alone occupied himself with this subject from the year 1786, when he published his first researches on integrations by arcs of the ellipsis, until the year 1825, when his *Treatise of Ellip'ic Functions* appeared.

Arcs of the ellipsis, being after arcs of the circle and logarithms one of the most simple transcendents, might become in some sort a new instrument of calculation, if we were once familiarized with their properties and possessed ready means of calculating them with precision. M. Legendre applied himself to this important subject in two memoirs inserted in the volume of the Academy of Sciences for 1786. In both of them the author demonstrates, by means peculiar to himself, that the rectification of the hyberbola depends on that of the ellipsis and presents no special transcendent, and in the second he shows that in an infinite series of ellipses formed after the same law we can reduce the rectification of one of these ellipses to that of two others taken at choice in the same series. This, he says with characteristic modesty, is one step more in a difficult path.

In the first memoir M. Legendre gives convergent series adapted for the easy calculation of the length of an arc of an ellipsis, whether in the case in which the elipsis but slightly eccentric approximates to a circle, or in that when, greatly elongated, it recedes but little from its greater axis; and in the second he adds:

> If the zeal of calculators could furnish us with tables of arcs of the ellipsis‡ for different degrees of amplitude and eccentricity, and each arc were accompanied by the coefficient of its partial difference, we should have the means of integrating by these tables a very large number of differentials, and especially all those which MM. d'Alembert and Euler have referred to the arcs of conic sections.

M. Legendre had then attained the age of 34 years; he knew not that it would be permitted him to labor till that of 80 years, and that unassisted he would himself accomplish the task of which he here traces the programme.

In the course of these two memoirs, and particularly towards the end of the second, he indulges himself in a just tribute of praise to the learned geometers (Euler, Landen, and Fagnani) who, before himself, had demonstrated, in a differ-

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* R being a radical of the form in question and P a rational algebraic function, all these transcendents are comprised in the formula $\int \frac{P\,dx}{R}$.—Legendre, *Mémoire sur les Transcendantes elliptiques*, p. 4.

† Landen published his researches in the Philosophical Transactions, and still later in a special work entitled, *Mathematical Memoirs Respecting a Variety of Subjects*, by John Landen, F. R. S.: London, 1780.

‡ See the volume of the Academy of Sciences for 1786, pp. 618 and 644.

ent manner, a part of the theorems with which they are filled to profusion.* But, in the publications of 1786, remarkable as they were, these rich materials hardly yet formed a completed edifice, and M. Legendre was not long in perceiving that this subject, and in general the theory of transcendents whose differential enters into the form above indicated, required to be treated in a manner more methodical and thorough. This he undertook to do in a *Memoire sur les transcendentes elliptiques*, read by him to the Academy of Sciences in April, 1792, and published towards the end of 1793, in which he proposed to compare among themselves all the transcendents in question, to class them according to their different kinds, to reduce each of them to the most simple form of which it is susceptible, to estimate their value by approximations the most prompt and facile; and, in fine, to form from the collective theory a sort of algorithm which should serve to extend the domain of analysis.†

Taking, in its most general algebraic form, the differential already indicated as a point of departure for this kind of researches, he analyzes it with extraordinary address, lays aside all the parts which are integrable, whether by arcs of the circle or logarithms, and thus reduces it to its quintessence; that is to say, to the parts whose integrals are transcendents of a superior order. Then, transforming this remainder by means of circular functions, he reduces it to a form of wonderful simplicity, containing but five quantities:‡ an arc of the circle designated by the name of *amplitude*, null at the point where the integral commences, and developing itself in proportion as that is extended; a *modulus* always real and smaller than the unit, which, in the case when an ellipsis is in question, represents its eccentricity; a *parameter* of any magnitude, positive or negative, capable of being reduced to zero, but to which it would be useless to attribute imaginary values; lastly, two coefficients whose values, independent of all the rest, may be anything, provided they be not null simultaneously. The amplitude is the variable in relation to which the integration is made; it is null only at the point of departure from the integral. The modulus cannot be null without the expression being completely altered in its nature, but the three other quantities may be null independently of one another, or fulfil in their relations of magnitude certain conditions according to which elliptic transcendents are divided into three classes.

The second class is the only one which represents arcs of the ellipsis. The first class is a transcendent more simple than arcs of the ellipsis; it may itself be expressed by means of such arcs, but an arc of the ellipsis cannot be expressed by transcendents of this first class. The third class, on the contrary, the only one in which the parameter is not null, is more composite than arcs of the ellipsis.

The gradation which exists in the complexity of these three classes of transcendents is manifested especially by this circumstance, that transcendents of the first species may be joined with one another, by addition and subtraction, so as to form a sum constantly null. Transcendents of the second species may unite in like manner, so as to form a sum whose value is expressed in terms

* "I shall not conclude this article," (XVI of the memoir,) says M. Legendre, "without giving notice that the greater part of the propositions contained therein have been discovered by M. Euler, and published in the 7th volume of the *Nouveaux Mémoires de Petersbourg* and in some other works, a fact of which I was ignorant when I was engaged in these researches. But the difference of the methods may throw new light on this subject, and moreover the comparison of the arcs of different ellipses, which is discussed in article XIII, has not, as far as I am aware, been before treated of by any one."—*Mem. l'Acad. des Sciences*, 1786, *p*. 676.

† Legendre, *Theorie des fonctions elliptiques*, Introduction, p. 3.

‡ For this he employs the following expression:

$$H = \int \frac{A + B \sin^2\phi}{1 + n \sin^2\phi} \frac{d\phi}{\sqrt{1 - c^2 \sin^2\phi}}$$

—*Mémoires sur les transcendantes elliptiques*, p. 17.

purely algebraic, like the celebrated integral of Euler, before referred to. Lastly, transcendents of the third species may also be united to form a sum of which the value, without being null or even algebraic, is notwithstanding of a more simple nature than each of the former in itself; for it may be expressed by arcs of the circle and logarithms, which are the most simple of transcendents.

These differences, and several others which exist between the three species of *elliptical transcendents*, suffice to vindicate the division established by M. Legendre; but, at the same time, they do not prevent our perceiving a profound analogy between all these transcendents which justifies their union under the same denomination. The first and second species may be expressed by arcs of the ellipsis; the third is the most compounded, but it has so much analogy with the two others that all three may be regarded as forming but one and the same order of transcendents, the first after arcs of the circle and logarithms. As M. Legendre elsewhere says, "the denomination of *elliptic function* is improper in some respects; but we nevertheless adopt it on account of the great analogy which exists between the properties of this function and those of arcs of the ellipsis."

M. Legendre resumed these questions with several others in a great work in three quarto volumes, which he published in 1811, 1816, and 1817, under the title of *Exercises de calcul intégral sur divers orders de transcendantes et sur les quadratures.* In this work, part of which was devoted to two classes of definite integrals, to which the author has given the name of *intégrales eulériennes*, he occupied himself also with a great number of questions about the integral calculus, into the details of which it would be difficult here to enter; but the most extensive and in his eyes the most important part was that which treats of elliptic functions, of their application to different problems of geometry and mechanics, and the tables necessary for the use of those functions. Finally, in 1825 and 1826, he combined anew all his results, with the developments and improvements which incessant labor had enabled him to supply, in a work entitled *Theorie des fonctions elliptiques.* This first appeared in two volumes, followed at a later period by three supplements, which constitute the third and last volume.

Among the improvements which M. Legendre bestowed on his previous labors when he published them anew in 1825, one of the principal was the discovery of a second scale of *modules*, different from that which alone was known at the time of the publication of the exercises on the integral calculus. "This second scale," as he remarks in the 31st chapter of the first volume, "completed in many respects the labors of the author upon this theory; it afforded an easy method of arriving at many striking results of analysis which till then it had been impracticable to demonstrate except by very laborious integrations. By the combination of the two scales the transformations of functions of the first species could be prodigiously multiplied; this the author has made evident by constructing a sort of tessellated table (*damier*) infinite in its two dimensions, all the divisions of which might be filled by the different transformations of which one and the same function is susceptible."

The development of the properties and uses of elliptical functions, considered with this generality, composed the whole first volume of the publication of 1825. The second was devoted, in part, to tables intended to facilitate the conversion of the integrals obtained into numerals. Calculated by the author himself with the greatest precision, these tables constituted in themselves an immense labor. "By means of them," said M. Legendre, "the theory of *elliptical* functions, enlarged and nearly completed by many successive labors, might be applied with almost as much facility as those of circular and logarithmic functions, answerably to the wishes and hopes of Euler."

After the developments which the theory of elliptical functions had received by the discovery of the second scale of modules, further progress seemed scarcely

probable; but the fecundity of the methods created by M. Legendre was such that results which he had hardly ventured to anticipate were very soon realized, and I abridge, in transcribing, the terms in which he speaks of this event in the advertisement of the third volume:

A young geometer, M. Jacobi, of Kœnigsberg, who could have had no knowledge of the treatise of elliptical functions, had succeeded, by his own efforts, in discovering not only the second scale of which we have been speaking, which is relevant to the number 3, but a third which is relevant to the number 5, and he had already acquired the certainty that there must exist a similar one for every odd number proposed. * * * This theorem being established for every odd number, it was easy thence to conclude that for every integer or simply rational number may be formed a particular scale of modules, which will give rise to an infinitude of transformations of any one function of the first species, which transformations will be all determinable algebraically. * * * The hopes inspired by the first successes of M. Jacobi have been since justified by new publications. * * * It remains for me (says M. Legendre in continuation) to speak of the admirable researches on the same subject which M. Abel, a rival worthy of M. Jacobi, has published nearly at the same time. The first memoir of M. Abel forms in itself an almost complete theory of elliptical functions considered under the most general point of view. * * * A second memoir of his presents very remarkable results: First, on the division of the particular function of which the modulus is sin. 45°, and which represents arcs of the lemniscate; secondly, on the general transformation of functions of the first species, by which, says the author, we are enabled to demonstrate, in a very simple and direct manner, the two general theorems previously published or announced by M. Jacobi.

We shall not enter into other details (says M. Legendre in conclusion) respecting the labors of these two young geometers, whose talents have dawned upon the learned world with so much brilliancy. It will readily be conceived that the author of the present treatise would be prompted to hail with cordial applause discoveries so greatly promoting that branch of analysis of which he may claim to be in some sort the founder. Hence has originated the design of enriching his own work with a part of these new discoveries, while presenting them under a point of view at once the most simple and most conformed to his own ideas. Such is the object of the two supplements which follow, and of those which, in the sequel, he may unite with them in order to form the third volume of his treatise.

Rarely has such sincere and emphatic recognition been extended to disciples worthy from the outset of being counted as rivals; but M. Legendre still further enhanced this recognition by the unaffected and spontaneous warmth with which the paternal tenderness naturally felt for a theory created by himself, and developed during more than 40 years by his single efforts, was reflected on his young competitors. Persons who, at that epoch, attended the sessions of the Academy will not have forgotten the artless effusion of feeling with which M. Legendre hastened to communicate to his colleagues the first letters received on a subject so interesting for science and for himself. It might be said that the elliptic functions did no less honor to the nobility of his sentiments than the profundity of his genius.

These first impressions were not modified by subsequent reflection, and M. Legendre concludes with the following paragraph the third supplement to the *Théorie des fonctions elliptiques*, by which that vast labor is closed:

We shall here terminate the additions which we have proposed to make to our work by taking advantage of the recent discoveries of MM. Abel and Jacobi in the theory of elliptical functions. It will be remarked that the most important of these additions consists in the new branch of analysis which we have deduced from the theorem of M. Abel, and which had remained until now wholly unknown to geometers. This branch of analysis to which we have given the name of *theory of ultra-elliptic functions* is infinitely more extended than that of elliptical functions, with which it has very intimate relations; it is composed of an indefinite number of classes, each of which is divided into three species like the elliptical functions, and which have besides a great number of properties. We have been able to enter but partially into this subject; but that it will be progressively enriched by the labors of geometers can hardly be doubted, and as little that it will eventually prove one of the most efficient parts of the analysis of transcendents.

These lines, dated March 4, 1832, may be regarded as in some sort the scientific testament of M. Legendre, who died within a year thereafter. M. Abel, in whom he reposed such high hopes, had descended to the tomb several years before him; M. Jacobi followed in 1849; but the anticipations of M. Legendre have not the less been realized, as well by the labors of M. Jacobi himself as by those of our learned colleagues, MM. Liouville and Hermite, and other distinguished geometers.

I might still further speak of important labors published by M. Legendre on the *integrals*, styled by him *eulerian*, from the name of Euler, who had first occupied himself with them, labors which occupy a large space in his exercises on the integral calculus, and which he partially introduced, while he improved on them, in the second volume of his theory of elliptical functions. I might also show how, parallel with the employment of *elliptic transcendents*, he opened the way to the numerical realization of a vast class of integrals by the tables which he has given for calculating the new transcendent, designated by him under the name of the function *grand gamma;* but although M. Binet has shown that the labors accessory to those which M. Legendre has given to the public on these subjects alone, would constitute no inconsiderable title for a distinguished geometer, I should fear to weary the attention of my auditors by dwelling at greater length on topics of this nature.

Like Euler, his model, and like many other great geometers who preceded him, M. Legendre prosecuted his labors to the last without having to regret any enfeeblement of his faculties; the volume of our memoirs, which immediately preceded his death, contains one of his studies upon a difficult question of the theory of numbers. He was then 80 years of age.

So vigorous an organization could scarcely be broken up without great suffering. The malady which terminated the life of our colleague was long and painful, but he endured it with firmness, without indulging any illusion as to its fatal issue, and with a resignation which, as was said by M. Poisson at his grave, must have been rendered difficult by the happiness of his home, the tenderness and fond solicitude which there surrounded him. Always characterized by a spirit of self-renunciation, he had often expressed the wish that in speaking of him no mention should be made except of his labors; but the same silence is not imposed on us as regards the noble actions which the faithful companion of his life, the depositary of his thoughts and purposes, continued to perform in his name after his death.

M. Legendre had not forgotten what, in his youth, he had owed to the learned and estimable men who had divined and fostered his talents. Madame Legendre continued to testify the interest which her husband had exhibited towards pupils of the Polytechnic school, who happened to be scantily endowed with the gifts of fortune, and paid in succession the charges of several of them. Having become possessor of the last editions of those works which M. Legendre had printed at his own expense, she distributed them liberally, in order that they might more promptly subserve the advancement of science; and the year before her decease she presented, through the Bureau of public instruction, 40 copies of the Theory of elliptical functions to the principal libraries of France, a donation for which thanks were addressed to her by the worthy minister M. Fortoul, in the name of the state. At her own death, in 1856, she devised to the commune of Auteuil, for a vicarage and school, the country house in which she had last lived with M. Legendre.

Full of devotion and admiration for the memory of one whose name it had been her happiness and pride to bear for 64 years, she preserved to her last day an unaffected and religious respect for all that had pertained to him. The survivor of M. Legendre for 25 years, she died at a somewhat more advanced age than he, from the effects of a long and cruel malady, against which she exerted the force and resignation of which he had given her the noble example. She had lost all her family, allied to that of our celebrated painter Robert Lefévre, and having never had children, she expired at the age of 82, surrounded by the pious care of persons whom the graces of her mind and her constant amiability habitually assembled around her, and who have preserved for her memory a filial attachment. With her, completely disappeared a name in which France will never cease to pride itself.

Lagreange was the reformer of analysis. By rendering more evident some of

the bases of that science, he has conferred upon it greater force, at the same time that by his immortal discoveries he has extended its domain. One of our greatest geometers has dwelt with admiration on the perfection of his analytical style.* Clear and smooth as the verses of Racine, the formulas of Lagrange have augmented the number of the adepts of science, while they have facilitated their labors. *Laplace*, in applying to the laws of the universe the faculties of a geometer of the first order, advances a claim to be considered as the lawgiver of the celestial movements. By his vast acquisitions in the empire of nature, he has earned a title to be styled the Newton of France.† *Legendre*, more pro found than popular, was our Euler; like Euler and after his example, he has bequeathed to the future a multitude of those analytical results which genius alone knows how to obtain, and which enrich in perpetuity the domain of the human intellect.

Clairault, *d'Alembert*, *Euler* were the continuers of *Newton* and *Leibnitz*. After them, *Lagrange*, *Laplace*, *Legendre* have held with a grasp not less firm the sceptre of mathematics. The Academy may be congratulated that it has counted in its ranks and can still count at the present day more than one successor of these great men.

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* In his *Eloge* of Laplace, pronounced June 15, 1829, before the Academy, where M. Legendre still occupied a seat, M. Fourier took occasion to make some interesting remarks on the discoveries of Lagrange and the character of his works. The following words occur: "All his mathematical compositions are remarkable for a singular elegance, for the symmetry of forms and the generality of methods, and, if we may so say, for the perfection of the analytic style." (*Mém. de l'Acad. des Sciences*, t. x, p. 6, 1830.)

† It was M. Cuvier who, in one of his academic discourses, conferred on him this proud qualification.

MEMOIR OF PELTIER.

By his son, F. A. Peltier.

[TRANSLATED FOR THE SMITHSONIAN INSTITUTION BY M. L. WOOD.]

[The following sketch of the life and labors of Peltier by his son, though perhaps warmly colored by filial partiality, scarcely does justice to his character. He possessed in an eminent degree the mental characteristics necessary for a successful scientific discoverer; an imagination always active in suggesting hypotheses for the explanation of the phenomena under investigation, and a logical faculty never at fault in deducing consequences from the suggestions best calculated to bring them to the test of experience; an invention ever fertile in devising apparatus and other means by which the test could be applied; and, finally, a moral constitution which sought only the discovery of truth, and could alone be satisfied with its attainment. Deprived in early life of the means of mental culture, and not commencing the study of physical science until after the age of 40, it is not surprising that he should have in some cases presented to the world the results of his investigations in a form little favorable to their proper appreciation; or that, considering his antecedents, the savants of France should not have conceded to him at first the honors to which he was justly entitled. According to Bacon, foreign countries like future times are the dispensers of justice: and this is verified in the case of Peltier, whose labors were more highly prized in Brussels than in Paris, and whose more important contributions to science are found not among the memoirs of the Imperial Academy of France, but among those of the Royal Academy of Belgium.—J. H.]

Jean Charles Athanase Peltier was born at Ham, in the department of Somme, the 22d of February, 1785. His parents were poor, his father following the trade of shoemaker in the town of Ham; but if they were but poorly favored by fortune, they were well endowed by nature; the father of Peltier being a man of firmness and capacity, and his mother an active and industrious woman.

Peltier inherited the qualities of his parents, evincing at an early age a quick intelligence, great perseverance of character, a remarkable spirit of order, and, above all, a love of labor which unfortunately led him to overtask his powers and consigned him, at a later period, to a premature grave.

He was first sent to school to the schoolmaster of the place, who most probably only taught him to read and write, he himself not knowing much beyond that. He was afterwards placed under the care of a vicar, who took him for a chorist, taught him French, a little arithmetic, and even a commencement of Latin.

From this time Peltier evinced a very decided taste for mechanics. At the age of ten years he took a clock to pieces, cleaned it, and put it together again. At this period also, he gave evidence of that spirit of observation which never left him. One evening he was on the promenade of the town, earnestly regarding the heavens; several shooting stars appearing, he followed them with his eyes with intense interest, not doubting even then that some day he should have occasion to occupy himself with them more seriously.

From the predilections his son had shown, the father of Peltier decided to have him taught the trade of clockmaking; to which end he placed him in

apprenticeship to a German named Brown, who had been taken prisoner at the time of the first campaigns of the republic, and had subsequently established himself at Saint Quentin. In character he was brutal and passionate, and the young apprentice had much to suffer from his cruel treatment. This natural violence of character too was much increased by the condition of the political world at that time; for Brown, loving his own country to fanaticism, most keenly desired the success of the Austrian arms. This was in 1800; the moment of the glorious campaign of Moreau into Germany, and the second conquest of Italy; and the year of Marengo and Hohenlinden. Every day that the paper brought news of a victory—and at that time this was of frequent occurrence—there was redoubled bad treatment and vexation for Peltier. Nor was this all: Brown, who himself had no fondness for study, refused to his apprentice this privilege, and this was an additional means of tormenting him. For some little time Peltier, the day's work being done, would read in his chamber by the light of the candle furnished him; but Brown, discovering this, forbade the use of one. By the strictest economy he now procured the coveted light from his own scanty means, and continued to read at night; but this also was prohibited. Forced to yield, Peltier at length watched for the nights when the moon shone clear, and opening his window softly, would thus read a few pages by stealth. This, too, Brown managed to prevent. Apprised of these facts, Peltier's father withdrew his son from this uncongenial domicile and succeeded shortly afterwards in dissolving the connection.

Peltier had been two years in Saint Quentin. On leaving this place he went to Paris, where he became apprentice to a clockmaker by name of Métra, who himself worked for the celebrated Bréquet. This was at the close of 1802.

The father of Peltier, who had never been to Paris and had no idea of the expense of living there, only allowed his son one franc a day for his support. With this pitiful sum the poor boy was to provide himself with board and lodging. Compelled to suffer many privations, Peltier appealed several times to his father; but he, judging Paris by his own little town, imagined the increase of allowance demanded by his son to be meant solely for indulgence in pleasure, and refused. Peltier very soon became seriously ill; and, hurt at the want of confidence manifested by his father, forbade his friends to write to him, resolving to abandon himself to his illness and to die without informing his parents of his condition. Fortunately his friends took no notice of his prohibition, and wrote to his father, who came in tears to find his son and carry him back to his native country, where he soon recovered.

On his return to Paris, Peltier set himself to work at clockmaking with more ardor than ever. At the close of 1803, however, he was for a while diverted from his peaceful occupations by other and entirely new ideas.

The peace of Amiens had lasted but a short while, and war with England had been speedily rekindled; a universal enthusiasm reigned throughout France; departments, cities, corporations, all vied with each other in offering ships, frigates, and even boats for the public service.

Peltier could offer nothing, being without means, but he *could* give his life, and he resolved to enter the navy. Not wishing, however, to engage as a common sailor, he worked incessantly in the hope of being received into the naval school at Brest. Nor was this all; for, not content with his own intentions towards his country, he recruited three of his comrades and bound them to join the army with himself. For a while all went smoothly; but as the fatal hour approached, the courage of the three comrades waned; and when the decisive moment arrived, Peltier found himself successively abandoned by his proposed companions, and left to execute his designs alone; this he would certainly have done but for a circumstance which he had not foreseen. In order to enter the naval school at Brest, it was necessary to obtain the consent of his parents; and he had already written them on this subject. His mother, learning his

design with the deepest grief, made many efforts to dissuade him from his purpose; but in vain. When, however, at last, she received the news that all was in readiness for his departure, and that he only awaited their consent, she was seized with a despair that rendered her seriously ill; and the father of Peltier, communicating to the son his mother's condition, terminated his letter thus: "If you persist, I will send you my consent, but it will kill your mother; and remember that you will have but yourself to reproach for her death." The alternative, thus put, admitted evidently but of one solution, and Peltier renounced his design.

Released from the ideas which had for a while so entirely occupied him, Peltier set himself again to work, and it was not long before Bréquet, discerning his talent, attached him directly to himself as a workman, and shortly after intrusted him with the most difficult part of horology—the construction of chronometers.

After remaining about two years with Bréquet, Peltier left him with the intention of establishing himself in business. For a while, however, he was on the point of uniting himself to Berthoud, who offered him very advantageous conditions; first, a very good salary; second, that at the end of six years he should be associated with himself in the manufacture of marine watches. This offer certainly merited reflection. After some hesitation Peltier finally refused; he would have been obliged to engage for six years, and live in Argenteuil at a period when communication was not as prompt nor easy as it is to-day. Peltier preferred his liberty; and, establishing himself in 1806, was shortly after married to Mademoiselle Dufant. For nine years he remained honorably engaged in trade; retiring from business in 1815, on the death of his mother-in-law.

Madame Dufant left him master of a very moderate fortune, the proceeds of which were considerably restricted by the disturbed condition of affairs; but Peltier, having no expensive tastes to gratify, remained contented with it, that he might from that time give himself up entirely to his natural inclination for study; besides which, energy and method produced by degrees their natural fruits; so that towards the close of his life he was possessed of a competency, which permitted him to occupy himself exclusively with his scientific labors.

The activity of Peltier's mind prevented him from restricting himself to the narrow limits of his trade; and always while studying and working at horology he was occupied first with one thing and then another, as the taste or inclination of the moment prompted him. At the time of which we speak, literature and literary persons were held in high regard in the empire; and Peltier's age inclining him to such pursuits, he devoted himself exclusively to books. He read, wrote or dictated constantly; reading while eating or walking; and even in the evening, when at work on his bench, listening to his wife who read aloud. It is thus that he read Voltaire, Rousseau, Buffon, the Correspondence of Grimm, and the geography of Malte-Brun; in short, everything that he could borrow, the scantiness of his fortune not permitting him to indulge in the purchase of books. He not only read, but composed. While still a journeyman, he wrote a melodrama. Later he applied himself to the study of poetry, and has left a comedy in verse completely finished, and has even published a criticism on the comedy of the *Deux Gendres* of Etienne. It was generally in putting together his clocks that he composed. Leaving his house, paper and pencil in hand, he would, while walking, compose his verses, and when he had them properly arranged in his own mind, would stop and write them. The real bent of Peltier's mind was rather towards the sciences and severer studies than literature or poetry; but he yielded for the time to the ardor of youth and the fashion of the moment. Still we find in what he has left real imagination, and a sprightliness throughout which is extraordinary. In general the versification is somewhat neglected; but this is by no means surprising, he very

often not having the time to review what he had written; but here, as elsewhere, his ideas are not at fault.

Retiring from trade at the age of thirty-one, Peltier resolved to educate himself anew. He had doubtless read much, worked much, and exercised his mind on a variety of subjects; but he had never pursued a regular course of study He determined, therefore, as the first step to make himself master of Latin, and at the same time to teach it to his little son, then aged seven years, and whom he had, since his sixth year, taught English. Wishing at the same time that he taught the Latin to perfect the child's English, he bought several English and Latin grammars; but what was his surprise in examining them to find that they differed essentially from the French and Latin! This difference was the more singular inasmuch as these grammars, both teaching the same language, should have been entirely alike.

Peltier, not content with remarking this difference, set himself to work to ascertain the cause, which he found to be that both English and French confine themselves to rules for translating their language into Latin. Now when the Romans taught their children the rules of Latin grammar, it was by rules deduced from grammar in general, and not by telling them that such and such a turn of phrase in French or English should be rendered in such or such manner in Latin. Thus when we teach our children French, we do so independently of all foreign languages.

When Peltier had once seen this defect, he resolved to write for his son a grammar in which all the rules of the Latin language should be given in English. It was in 1816 that he undertook this work; somewhat later he took it up again, but in French; the change from one grammar to the other being but a small matter, the same language being taught in both, and the same rules given. He worked at this for some time, and made considerable progress; but it is far from being complete.

When this work was somewhat advanced, Peltier began to write an introduction for it. Now grammar being the art of expressing one's thoughts according to certain rules, he discoursed, in this introduction, of ideas, their origin and transformations, thus passing from grammar to ideology. At first it was only his intention to write an introduction, but little by little his plan enlarged, as the constant necessity arose of mounting higher into causes in order better to explain effects. It was first an introduction of a few pages; it very soon became an entire work. He abandoned it several times, but always seemed irresistibly drawn to take it up again.

It was his conviction that all the phenomena of the formation of ideas could and should be reduced to the simple undulation of the nervous fluid. The sensation composed, 1st, of the impression made on an organ, 2d, of the transmission of this impression to the brain, 3d, of the perception effected by the brain, was only, according to him, an undulation wrought in the nervous fluid, the starting point of which is any given organ, the stopping point the encephalon; when afterwards this undulation returns from the brain to the organ impressed, it becomes attention; when it returns from the brain to an ensemble of muscles, and is designed to cause motion, it becomes will. Memory he describes as a succession of undulations, similar in nature, and acting upon each other; while judgment is the sensation of the difference between *I (moi)* previously impressed in a certain manner, and *I (moi)* afterwards impressed otherwise.

It is far from my intention here to enter into any detail on this subject. Suffice it to say that ideology is one of the sciences on which he was most often engaged, and in which he has advanced the newest and most original ideas. Unfortunately his work on the subject is very far from being finished.

Prepositions are the most difficult parts of speech to define, and have very much perplexed all grammarians. Expressing the relations of persons and things to each other, they form one of the most abstract points of grammar.

We easily conceive of a noun; it is the name of a person or thing, or else the generalization of a quality; we understand an adjective or verb; but a preposition is infinitely more difficult of conception; it is neither an object, quality, nor act, but a relation between all these ideas; it is, in short, a something completely intangible. Led by his ideological studies on the one hand, and his studies of Latin grammar on the other, Peltier undertook, about the year 1820, a treatise on Latin prepositions. To this he applied himself assiduously for several years, and finally completed it. In 1826 he even had some thoughts of submitting it to the press, but, led off by other studies, he soon renounced his intentions.

At the time that Peltier was studying the formation of ideas with such care, Dr. Gall had opened his public courts in Paris, in which he expounded his theory of the development of the brain, and the localization of the faculties. Peltier, perceiving in an instant of what immense advantage such knowledge would be to him, studied with assiduity the lessons of Dr. Gall, and became, and to the close of life remained, his zealous partisan. Not that he thought the localization of faculties as maintained by Dr. Gall incontrovertible; he had not implicit faith in all his bumps, (to speak after the usual manner;) but he did believe sincerely and with reason in the fundamental principle of Gall's doctrine; that is, in the relation which exists between the mental and moral nature on one hand, and the development of certain parts of the encephalon on the other.

The confidence he had in the principle of this doctrine, however, did not prevent him from pointing out a few errors of detail. He made several objections to Gall himself on his cranioscopy; one, among others, having reference to the organ of perfectibility, and another to comparative sagacity. On this subject he wrote as follows: "I have never been able to understand how there could be an organ of perfectibility unless it should be made the centre of all the intellectual organs, which would be an entire subversion of your scientific principles. Mathematics, metaphysics, music, having each its particular organ, perfectibility cannot be a separate, universal quality; it can only be a greater development of a particular organ. Neither have I been able to comprehend the organ of comparative sagacity. All judgment is the result of a comparison; the mathematician compares and judges; so also the painter, the mechanic. Our knowledge does not come but by comparing and judging. The organ of comparative sagacity, then, is one that encroaches upon the others, and that is directly opposed to your theory of the localization of the faculties." The reply of Gall to these objections was far from being satisfactory.

The study of Gall's theory had made Peltier feel the necessity of studying the anatomy of the brain. This necessity once acknowledged, he set himself to work; he went into the amphitheatres and dissected like a novice, although he was at that time about 36 years of age. He did not, it is true, pursue the study of anatomy so far as is necessary for a physician or surgeon, but he studied enough to understand thoroughly the nervous system of man, and to have sufficiently correct ideas of all his other organs. The gross dissection of the brain and nerves showing him almost nothing of their inmost structure, Peltier endeavored to study them with magnifying instruments. But man stands highest in the scale of animal beings. Instead of studying the construction, assimilation, and life of so complex a being, it is much more rational to study them in beings of more simple construction. Transparent insects will perhaps let the secret of their existence be seen. Thus Peltier was led to apply himself to microscopy.

Perfectly insatiable in his desire for knowledge, Peltier attended at the same time the lectures of M. Flourens at the Collège de France, and the experiments in vivisection of M. Magendie. Electricity was just rising into great favor with physiologists; all was attempted to be explained by it. M. Magendie made dogs and rabbits digest by electricity; according to M. Dumas, muscular contraction was but electro-dynamic; nothing seemed able to resist its power, not even the generation of beings, the males being powerfully charged with positive electricity, the females consequently with negative: it was a general mania.

What *is* electricity? Peltier had now come to the study of this science—a study which was to occupy him exclusively during the last twenty years of his life, and on which he has left such a profound impress of his genius; but we see what detours he had made before arriving at this point, and what road he had travelled.

I have entered into these details because they seemed to me to offer some interest; we see in them the gropings to which a vigorous mind may give itself up before arriving at what is destined to constitute one day its study from predilection. The course followed by Peltier is, besides, I think, rooted in the very nature of the human mind; it is always towards the most abstract and complex ideas that man at first and from choice directs his studies; it is not until later, and little by little, that, instructed by experience, he at the same time simplifies and restricts his researches. History bears ample testimony to this. In the middle ages, on the revival of letters, men were occupied but with questions in metaphysics—the nature of the soul and its faculties—and, as if this were not sufficiently beyond their powers, they discoursed even on the nature of God. It was not until some time later that they consented to descend from these heights and study the material world: first the living world, anatomy and physiology; and lastly the inorganic world, physics, chemistry, geology, &c., &c.; so true is it that associated men, or the people, take but the same course as isolated men, or individuals.

It was about 1825 that Peltier commenced seriously to study physics; until that time indeed it had been to him but an accessory. In 1827 he bought in a public market-place an old electric machine and some Leyden jars; these were the first instruments he had at his disposal. At first he amused himself by drawing sparks; he then formed sparkling squares and tubes, and electric jumping-jacks, and many other amusing objects; a little after he tried more serious experiments; but he very soon discovered that this road could lead to nothing. By an electric machine, in fact, he could never have obtained other than static electricity; and static phenomena constantly reducing themselves to phenomena of attraction or repulsion, and to sparks, are very far from offering the variety and interest of dynamic phenomena. Weary of these experiments without result, Peltier very naturally turned his attention towards another source of electricity, the pile; it was, besides, of the Voltaic pile that physiologists made use in applying electricity to the phenomena of life. Peltier therefore very soon bought a trough pile, with which he made his first investigations into currents. Later he made for himself a very great number of these piles.

For several years Peltier labored without communicating to any one either his work or his discoveries. Knowing but little of the world, he had not had opportunity to compare himself with other men, and, ignoring completely the real worth of his intellect, did not dream that he could do anything worthy of being known. This diffidence rendered him extremely reserved, and he worked a long time in profound silence. His first communication to the Academy of Science was on the 19th of July, 1830, and relates to dry electric piles. The reason of this communication was as follows: It had been generally believed for a long time that dry piles were not capable of giving a constant current, and could not produce any chemical reactions. In 1830 M. Donné endeavored to throw light on this subject by new investigations. In his experiments he carried the number of couples to 25,000 and 30,000, without, however, increasing the usual size of the plates. He obtained thus phenomena of enormous tension, but could not get a current which was capable of effecting the least chemical action.

At this time Peltier had already comprehended the distinction to be maintained between the quantity and the intensity of a current. He therefore took up the experiments of M. Donné, but instead of increasing the number of couples, he increased their surface, and thus succeeded in reddening to the color of turnsole, and in decomposing water by means of a current of the dry pile. It suffices

for this that we take from 25 to 30 disks, provided only that their surface be a little expanded, say from one to two square decimeters. Such was the first scientific communication made by Peltier to the Academy of Science: this took place on July 19, 1830; and Peltier dying October 27, 1845, it was in this interval of 15 years that he wrote and published the labors and discoveries of which we shall proceed to give a rapid enumeration.

At the time that Peltier began to devote himself to experiments in physics, Nobili was in Paris, having come thither to illustrate his system of static needles which he had just invented for galvanometers. Peltier was forcibly struck by the sensibility which these instruments were rendered capable of acquiring by this ingenious modification, and set himself immediately to work to construct similar ones for himself. A short time afterwards M. De la Rive commenced his publications on the theory of the pile. This illustrious savant wished to prove that chemical action was the real cause of dynamic electricity, and endeavored to demonstrate this by analyzing the different phenomena of the currents by means of the galvanometer thus perfected by Nobili. Peltier thus found himself led, on one hand, to the thorough study of galvanometers, and on the other to experiments on the pile and on currents. The first communication that Peltier made to the Academy of Science bore marks of this double impulse. On July 19, 1830, he presented his note relative to dry piles; May 27, 1833, he laid before this learned body another note on the quantity and intensity of currents; July 22, of this same year, he presented them with a memorandum on the same subject; and finally, on March 10, 1834, he made known his galvanometer of deviations proportioned to its force.

Peltier had naturally great dexterity of hand, which had been still increased by his practice of horology; further, he was possessed of patience sufficient for any ordeal, never becoming disheartened, and never recoiling before any sacrifice of time or trouble which could lead to the desired end; and assisted besides by the counsels of a distinguished artist, M. Gourjon, he was enabled to give to his galvanometers a sensibility which permitted him to study the smallest forces, and consequently to discover phenomena of which he would never have suspected the existence had he had at his disposal only heavy and sluggish instruments. It was thus he discovered that, under certain determinate circumstances, a weak electric current can produce cold. He first made known this fact to the Academy of Sciences, April 21, 1834; later he inserted in volume 56 of the *Annals of Chemistry and Physics* a dissertation on the heat generated by electric currents.

In 1835 Peltier discovered the difference of capacity of the various metals for each kind of electricity. During this same year he published in volume 60 of the *Annals of Chemistry and Physics* a dissertation on electro-magnetic experiments. Until that time it had been assumed, for simplicity and facility in theoretic calculations, that magnetic repulsion was a force equal and contrary to attraction. In this dissertation Peltier proves that it is nothing, demonstrating that repulsion is by no means a special force like attraction, but that it is an effect of the disagreement of opposed motions sustained in their opposition by secondary causes and influences.

In 1830 Peltier again turned his attention to the quantity and intensity of currents, laying before the academy, May 9th, an article on this subject; and this same year he submitted to that learned body the curious fact of the formation of several individuals proceeding from a single animal that is subjected to lingering inanition. He published in volume 62 of the *Annals of Chemistry and Physics* a description of the electrometer which he had just invented, and which is certainly one of the most useful instruments with which he has enriched science; and he also presented to the Philomathic Society most interesting observations on vorticellæ, on the articulation of the claws of rhizopodes, on the influence of electric currents in the vegetation and evolution of animalcula, on the reproduction of arcellæ, &c. Finally, this same year, recurring for the last time to the

subject of the quantity and intensity of currents, he published a resumé of his works on this subject, in volume 63 of the *Annals of Chemistry and Physics.*

January 9th, 1837, Peltier presented to the Academy of Sciences a large work containing his experimental researches into the various phenomena which concur in producing the general result from electric piles; the 30th of the same month he inserted a note on the dynamic electricity engendered by friction. May 15 he made known to the academy the new hygrometer he had just invented, and his work on solutions and dissolutions; and, finally, on June 12, he laid before this same learned body his researches on the difference in the conduction of a circuit according to the direction of the current; and thus explained from natural causes a fact that M. De la Rive could not account for, except by admitting, in electric currents, interferences analogous to those of light.

In 1838 Peltier published in volume 67 of the *Annals of Chemistry and Physics* an article on the quantity of dynamic and static action produced by the oxidation of a milligram of zinc, and on the relation which exists between these two kinds of phenomena. Faraday had handled an analogous question before Peltier, and M. Becquerel has treated it since. These three gentlemen have arrived at this conclusion: that a dynamic degree represents an enormous static force; in other words, that a galvanometer, despite its apparent sensibility, is an extremely inert instrument compared with the electroscope. This same year Peltier made known the cause of secondary currents in liquids; and he published in the *Annals of Natural Science* two dissertations: one on a new kind of floscularia, the other on the structure of muscles. He also laid before the Philomathic Society his observations on the zoosperms of the frog; on magnetism by discharges along a bar; on the displacement of the axis of a magnetic needle during a prolonged deviation, &c., &c.

In the beginning of 1839, Peltier presented to the Philomathic Society an article containing most interesting observations on the difference in structure of the motor and sensitive nerves. At the same time he published in volume 71 of the *Annals of Chemistry and Physics* a very comprehensive dissertation. This dissertation is composed of two distinct parts: the first treats of the formation of tables in regard to relations which exist between the force of an electric current and the deviation of the needles of the multipliers—and certainly no one was more fit than Peltier to do this work; the second treats of the causes of perturbation in the thermo-electric pairs and the means of avoiding it. It is in itself an entire and profound study of thermo-electricity. Peltier examines in this work the effect of the bulk of the pairs and their number, of the size of the solderings, the extent of surface immersed, &c.

During the period we have just sketched, Peltier had also occupied himself with the study of meteorology, although in a cursory manner. In 1835 he placed on the house he occupied apparatus for studying the temperature and electric state of distant media. The apparatus with which he at this time studied the electric interchange between the earth and clouds was as follows: it was formed of a piece of copper wire surrounded with silk, and covered over with several layers of oil varnish; the upper portion of this wire was terminated by a tuft of platina wire, and was elevated about 25 metres above the earth; the lower end was also terminated by a platina wire, and immersed in a deep well of 12 metres. In the midst of the wire Peltier interposed at pleasure either a multiplier of 3,000 coils, an electrometer of his invention, or a simple electroscope of gold leaves. By the aid of this apparatus Peltier soon ascertained that the earth ordinarily gave indications of negative electricity; that, in general, there was a negative ascending current, but that in certain circumstances, and especially during storms, there was on the contrary very often an inverse current, that is, a negative descending current.

Later, in 1836, Peltier ascertained that during storms the negative ascending current acquired at times a considerable force, and then ceased altogether, giving

place to a negative descending current still more powerful. August 6 of this same year, especially, the storm that he was observing presented at least 25 of these inversions. He even ascertained that these sudden inversions did not take place in all their power until the rain precipitated itself from the clouds to fall on the ground; and, finally, he discovered that all storms were negative, but that the clouds surrounding them were in general of a contrary electricity, and that this was the reason why the commencement and close of storms always produce positive signs, while the storm itself gives but negative ones.

In 1838 Peltier noticed a fact which he afterwards often confirmed, namely: that snow alone never produces electric currents, while on the contrary sleet and hail invariably give them. When they come with snow it is because it is mingled with sleet. Finally, this same year, he called the attention of the Philomathic Society to the fact that the earth and all bodies resting upon it are naturally in a negative state; but that when in a storm the lower clouds are strongly negative, the earth and all appurtenant bodies, being beneath them, become positive; that is, they exist momentarily in a condition opposed to their ordinary state; and he thinks this change of electric state may be the cause of the general discomfort suffered by nervous persons during certain storms.

We see that Peltier was perfectly prepared by his observations and previous researches for the study of meteorology. He understood electricity thoroughly; he possessed galvanometers of great sensibility, by the aid of which he could estimate the smallest dynamic currents; he had invented an electrometer which could measure the smallest static tension; he had already made both curious and interesting meteorological observations, and he needed but some favorable occasion to deliver himself to the study of meteorology with all his characteristic ardor. This occasion the water-spout of Châtenay was not long in furnishing.

On June 18, 1839, a water-spout laid waste the property of M. Hérelle at Châtenay. The insurance company refused to pay damages, alleging that water-spouts were not electric phenomena. In order to satisfy himself on this point M. Hérelle sought Peltier, whose works had now begun to be known and appreciated. Solicited by M. Hérelle, Peltier repaired to the spot, and by virtue of his perfect knowledge of electricity soon determined the real character of this phenomenon. He first wrote a letter on this subject to the Academy of Science, July 15; later, his ideas becoming still clearer, he presented, October 28, a resumé of his researches, and in 1840 published his *Treatise on Water-spouts.*

From this moment Peltier found himself engaged for a long time in the study of meteorology; for, in consequence of his habit of never leaving unexplained a single phenomenon, he felt himself compelled to study the whole science, and with what zeal he did this we shall now see.

February 3, 1840, Peltier wrote to the academy explaining the fact of the entire destruction of a man by a thunderbolt; and the same day laid before them a sealed package on the grouping of clouds. May 4, he communicated to this learned body observations of great interest, made by aid of an electric kite, on atmospheric electricity during clear weather. May 25, he made known his researches on the phenomena which take place in the interior of metallic spheres charged with electricity, and deduced from them an explanation of the grouping of clouds. June 1, he complimented the academy by a presentation of his *Treatise on Water-spouts;* and, finally, November 30, he presented them with an article in which he demonstrated that the electricity produced by evaporation was only maintained by decrepitation. All these works, however, did not prevent him from continuing his experiments in electricity and his microscopical researches, so that, July 4, he presented to the Philomathic Society the interesting observation of a lucophre produced by efflux; and, November 16, made known to the academy his experiments on the origin of the zoosperms of the frog.

In 1841 Peltier continued to occupy himself with the same ardor on all that concerns meteorology; he ascertained the resinous tension of the earth, and dis-

covered the true cause of the electricity of vapors, (February 8, communication to the Academy of Science.) This same year he procured a barometer, and six months had not passed before he was able to comprehend the true cause of the oscillations of this instrument, placing in fact before the academy, April 25, 1842, a sealed package containing the resumé of his researches into the causes which vary the barometrical pressure. At the same time that Peltier made by his observations so important a discovery, he published, in volume 4 of the third series of the *Annals*, his great work on the cause of the electrical phenomena of the atmosphere, which may be regarded as the fundamental basis of all meteorology; he also ascended the Faulhorn, and there ascertained that mountains are possessed of all the properties of forelands, and that consequently their resinous tension is enormous. He explained the phenomenon of the coloring of mountains; studied the electrical phenomena of cascades; caught a glimpse of the cause of the different colorings of clouds; made, with M. Bravais and by request of M. Régnault, experiments on the boiling point of water in reference to different heights; and finally returned to Paris laden with his numerous materials. Hardly arrived in Paris, he gathered together, arranged, and made known all the facts he had observed, and published his dissertation on the different kinds of fogs.

In 1843 Peltier continued his labors, and prepared the memoirs with which his scientific career terminated.

November 2, 1844, he presented to the Brussels Academy of Science his great work on the cause of barometrical variations, and his researches on cyano-polarimetry; and this same year published in the *Archives of Electricity*, at Geneva, his memoir of electrical meteorology. He also made known to the Philomathic Society his observations on the electricity of vapor arising from boilers at high pressure; pointed out the different causes of error which might deceive students of meteorology, and added some points of detail to the general history of water-spouts, on occasion of the Cette water-spout.

Finally, in 1845, Peltier made known the cause of the oscillations observed by M. Liagre in spirit levels, and presented to the Brussels Academy of Science his dissertation on the cause of electrical phenomena, which concluded his scientific career, and which he unfortunately did not live to see in print.

We have now terminated the principal discoveries made by Peltier in micrography, physics, and meteorology. All these works, all these researches were effected at most in 20 years; and, indeed, it can be said that his meteorological labors only date from 1839. From having made so great a number of discoveries in so short a time, it is easy to understand in what a state of intellectual tension Peltier must have passed his life. For several years previous to his death his health had suffered much; but to all remonstrances of his friends and family he replied: "I would rather die 10 years sooner and leave behind me discoveries which will recall my name." In the month of July, 1842, Peltier went to the Faulhorn, there to make meteorological observations. The sudden change from a temperature of 30° above zero to one almost always below this point, materially affected his health, and, a short time after his return to Paris, resulted in a spell of sickness. His disease was not in its first stages dangerous, being but a slight intestinal affection, to cure which would have required at this time rest and quiet for a few months. But with his character, with that incessant activity which distinguished him, Peltier could not accept repose; he could exclaim with Hoche: "Give me a remedy for fatigue, but let it not be repose." Another cause there was which added still to the excessive excitement of his brain: he had laid the foundations of meteorology; he had established the basis, and he now wished to deduce its consequences and apply them to the different phenomena of nature. Nor was this all: it was long since he had had decided opinions on the nature of electricity; but never having drawn them up into regular form, he was afraid death might overtake him too soon for the work; so that, redoubling his energy and activity to accomplish his wish, his relapses became frequent, and his malady

soon assumed a most serious character. From the year 1844 a fatal issue was feared, although he still had strength sufficient to go into Belgium for the purpose of there introducing his various apparatus and his method of observation in meteorology.

In 1845 the disease continued to make such progress that it was soon impossible not to recognize in it a scirrhous stricture of the intestine; and to this he soon succumbed. The day before his death, although exhausted by suffering, he was still intent upon science—admitting several persons who came to consult him on the water-spout of Monville, among whom was M. Preisser, professor of chemistry at Rouen, with whom he had a long conversation on the cause of the disasters which had just taken place. In the evening he dictated some lines explaining the twisting which had been observed on the bark of certain trees; the next morning he still retained his consciousness, but, gradually losing it, died calmly and painlessly at 9 o'clock a. m. on Monday, October 27, 1845, having attained the age of sixty and a half years.

Peltier was of medium height and well proportioned; his build was somewhat spare, and his temperament at the same time bilious and nervous; his forehead was broad and largely developed; his face, something thin at the lower part, was extremely mobile, the expression of his features being quick and intelligent, while the contrast between his light blue eyes and heavy black brows gave to his face a most marked appearance. His sight was excellent, although somewhat impaired towards the last by his use of the microscope; and he had a delicacy of touch which he found invaluable in his manual labors. In an intellectual point of view there are few men who have been better endowed; his conception was prompt and facile, and he was at the same time a man of theory and of facts, never separating these two—a fact being to him but the round of a ladder by which he ascended to the cause. It was also often his lot to find in the discoveries of others relations which they had not themselves seen. His passion for study was incredible; it is impossible to conceive a correct idea of all that he learned and did, bearing throughout that sound, practical mind which so pre-eminently distinguished him.

In a moral point of view there has been and can be but one voice. It is known with what violence political passions rage, and how the least fault is held up to public view as a handle against an adversary. But his political adversaries, even the most bitter, respected and loved him profoundly, for his probity and loyalty were known and appreciated by all. Peltier had no ambition, or, rather, he had but one, and that was science. In 1834 the prefecture of the Seine offered him the mayoralty of the fifth ward of Paris, and he was given to understand that the cross of honor would be the speedy reward of his services in this new capacity; but he refused. Himself maintaining the most decidedly conservative opinions, he nevertheless could respect the views of his adversaries; and, although he was frequently engaged in oral strife, those even whom he had combatted with the most energy could not leave him without regret. It was, indeed, for every one a day of grief when he died.

On the 29th day of October, 1845, a great concourse of savants and friends conducted him to his last home, amidst the universal grief. Among these were MM. Régnault and Milne Edwards, members of the Academy of Sciences; M. Desbassayns of Richemont; Dr. Conneau, MM. Bravais and Martins, M. Boutigny d'Evreux, M. L. Bréguet, M. Donné, M. Lemercier, M. Frédéric Gérard, M. Lesueur, M. Silberman, M. Doyère, M. Lassaigne, M. Bréon, M. Véc, mayor of the fifth ward; MM. Converchel and Lourmand, who had been his colleagues in the primary committee of instruction; the officers of his old company, and many others too numerous to mention.

Arrived at the cemetery of Père-la-Chaise his body was deposited in a provisional vault, and two discourses were pronounced over his tomb—one by M. Milne Edwards, as president of the Philomathic Society, of which Peltier was a mem-

ber; the other by M. Frédéric Gérard, who had known him but a few years, but to whom the time, short though it was, had sufficed to give a just appreciation of his qualities. These discourses were as follows:

DISCOURSE OF M. MILNE EDWARDS.

"It is not in the midst of the sad scenes surrounding the tomb that we can give ourselves up to the cold estimations of science, and judge impartially the works of a man who has long been our colleague. I shall not then endeavor to recall here all that M. Peltier has done for the advancement of human knowledge, nor to expound the ingenious views which led him to explain and reproduce, by single experiments in the laboratory, the most sublime phenomena of which the atmosphere is the seat. Historians of science will have the grateful task of registering his works, and will gladly render him the praise which is his due. But before the earth-clods close over his remains let me be permitted to pay to his memory this last tribute of respect, in the name of a body of men whose watchwords are *study* and *friendship*. The Philomathic Society will long honor the memory of M. Peltier. We will not forget the frequent and interesting communications in which he has given account of his curious researches, and his name will be often cited among us when we wish to place before the eyes of our rising generation examples of disinterested love of science and patient perseverance in the pursuit of knowledge, which may excite them to emulation. The recital of his life will be pre-eminently instructive to those who, in the beginning of their career, feel discouraged by their isolation, and fear that they can, unsupported, acquire neither fame nor fortune. They will see from the example of M. Peltier how, with firm will and undaunted spirit, a young man alone in the world, and without resource except such as is furnished by a powerful organization, can triumph over the numberless obstacles by which he is surrounded, and conquer, little by little, all that is wanting—instruction, wealth, and fame, all well acquired.

"Such, indeed, has been the life of M. Peltier; and had not death so ruthlessly come prematurely to interrupt the course of his labors, so strongly impressed with the seal of originality, he would have received the reward due to his merit, for doubtless his peers would soon have chosen him to be one of the representatives of that science he cultivated with such éclat.

"When in a few days our society resumes her labors, she will learn with grief the loss that I now so deeply deplore; and on the list of members which she most regrets and loves will be inscribed the name of Peltier beside those other illustrious names, Dulong, Fresnel, and Savart."

DISCOURSE OF M. FRÉDÉRIC GÉRARD.

"It is a noble thought that gathers around a grave the friends of him whose remains are to be laid therein; it is the last homage we can render to his memory; and the words pronounced over his coffin, resting deeply engraved in the mind, are an instructive lesson to all who hear them.

"If a pompous eulogium is expected for those who have performed glorious actions, a few simple and touching words are the fittest tribute to the memory of that man who has applied himself to the art of living well, and has consecrated his leisure hours and all his mind to the advancement of knowledge.

"Such was he whom death has taken from us before the time at which he usually strikes those who have passed the critical period of life.

"A few words on his earliest years will show what there was of noble in this man's life, and will be the highest eulogium we could pronounce over his tomb.

"Born at Ham, in 1785, in mediocre condition, but of an honest and intelligent father, Jean Charles Athanase Peltier was placed, at the age of fifteen years, under the care of a German clock-maker living at Saint Quentin—a hard, unmerciful man. It was at this time that France in arms battled against all Europe;

and each time that the public journals announced the success of republican arms, his wounded national pride vented itself upon his pupil, who experienced a malicious pleasure in informing him of the reverses of the German hordes. As he offered to the eager lad but little knowledge, Athanase, impatient of a yoke which nettled his pride, ran away and went to Paris.

"This was in 1803, when Bréguet held in this city the sceptre of elevated horology. Peltier, having heard of his fame, presented himself before him with that naïve confidence so precious an accompaniment of youth, and asked to be employed in his workshop. Struck with the frank and open manner of the young Picard, the great mechanic granted his request, and placed him under one of his most skilful workmen. A few years later, the young horologer of Ham was promoted to a place under Bréguet himself, and very soon intrusted with his most important works.

"Fortune smiling on his persevering efforts, Athanase became himself head of an establishment of horology. Until that time he had applied his intellect to the study only of mechanics; but he then began to feel that this branch, cut off from general knowledge, could not satisfy him; and so occupied himself with literature, poetry, and philosophy; this last science especially suiting his grave and meditative cast of mind.

"Married in 1806, and becoming a father two years later, he formed the resolution of himself directing his son's education. This was for him the beginning of a new life. Without neglecting his business, he attended the public courses, and devoured the lessons of the great masters with the eagerness of a spirit impatient of all trammels. Gifted with a perspicacity equalled only by his perseverance, overcoming with giant strides all difficulties, the modest partner of the labors of Bréguet could soon compete with those who had commenced their life with study, and could discuss with them the most abstruse points in science.

"At the close of 1815 he quitted his establishment and succeeded his father-in-law, who had been farrier to the Emperor; but the feebleness of his health, and his extreme fondness for study would not permit him to accommodate himself to a profession which requires more of physical force than of mental; and hence he was not long in abandoning the situation to return to his favorite studies with renewed zeal.

"In a short time the son of M. Peltier, under the intelligent direction of his father, began to study seriously, and designed himself for the profession of medicine. Thenceforth the career of the elder Peltier was irrevocably determined; he occupying himself exclusively with mathematics, physics, and natural history. He brought to bear on these studies a cool, clear mind, a sound and severe judgment and a fertility of resources which characterize the observer; qualities rarely found united in one man; to which he added a skill in handicraft and a precision which, acquired as they were in his earliest years, enabled him to make his own instruments, and to add to others the modifications necessitated by their use. He loved to repeat and explain the experiments in physics at which he had assisted; and, novice at first, he very soon became skilful in handling the most delicate instruments. He now also began to give his whole attention to the study of electrical phenomena.

"He for a long time followed assiduously, but in silence, the sittings of the Academy of Sciences; meditating deeply on problems in electricity, repeating, multiplying his observations, varying them incessantly, and perfecting constantly the means of investigation.

"1830 found him laboriously occupied on these matters, without one single line having appeared in public to reveal his severe and profound studies. At this time the question of dry batteries was much discussed; this subject roused him, and, seizing it, he treated it with that accuracy of judgment which announces a man habituated to the severest labors of the mind. From 1833 to 1845 was

occupied by a succession of works numerous and varied on the most obscure points of electricity. These were never theories *a priori*, mere playthings of the imagination, but experiments and minute researches pregnant with new views and marked by the most subtle penetration. The returns of the Academy of Sciences, the Bulletin of the Philomathic Society, of which he was an honored member, the public library of Geneva, the Annals of Chemistry and Physics, all attest his incessant activity.

"Dynamic electricity and galvanism, that important branch of physics which is so nearly allied to the great phenomena of life, were to him the object of numerous researches; but he directed his special observations to meteorology, a science which so imperiously demands an attentive observer, a skilful experimenter, and a philosopher who knows how to deduce results from his observations; and on this subject he indeed threw light. His works on the electricity of clouds, on fogs, and his fine treatise on water-spouts, would suffice to assign him a distinguished place among physical philosophers had he not other claims to the remembrance of the friends of science: I allude to his last works on electrical meteorology and barometrical variations.

"I shall also call to mind his considerations on ether, in which he rises to the greatest heights of abstraction without, however, quitting the stronghold of experience, a characteristic which is observable throughout all his works.

"I must not forget, too, to cite his experiments on microscopic life, which form a portion of his far too limited zoological observations. Studying in them the phenomena of the production and disaggregation of infusoria, he arrived at a belief in the heterogeneous origin of all these forms of life. It is pleasant to follow him in these minute experiments, where we recognize at every step the rigorous method of the philosopher, and in which he studies this infinitesimal life with a happy daring which permits him to read its secrets as easily as the evolutions of great bodies.

"But a life so laboriously consecrated to study, and so productive of fruit for science could not be without its sacrifices. The observations made by M. Peltier on the Faulhorn, in 1842, in connection with M. Bravais, laid the foundation of that disease which has to-day bereft us of him. From that fatal period his strength diminished, and his body wasted away; but his mind lost none of its original vigor, and he ever retained his passionate love for science. It was, indeed, during these last three years that he published in the Brussels Archives of Electricity and Memoirs of the Academy of Science his most important works.

"Towards the close of this year his health became more and more feeble, and the disease which preyed upon him soon gave too clear warning of his approaching end. He spoke of it without affectation, and with the quiet resignation and calm philosophy of one who feels and understands that the goal of life is death.

"His extreme sufferings, the prostration of his strength, his ever-increasing debility, that precursor of dissolution, could not diminish the ardor with which he still devoted himself to his favorite occupation, even revising and correcting towards the last the impression of a general treatise on physics, which will appear as a posthumous work, and is the last emanation from his great and noble mind.

"The numerous materials he has collected will not, we hope, be lost to science; and only when we reap the fruit of these will we understand the full extent of the loss we have this day sustained. Justice will then be rendered him; all will deplore his untimely death, but, alas! without avail.

"It is but two days since he conversed for several hours with a scientific gentleman of Rouen and the proprietors of Monville on the cause of the disasters of that commune; pointing out to them, with his usual clearness, the part he considered the electric fluid to have borne in this fearful event. This long and serious conversation, while it aggravated his physical exhaustion, did not pre-

vent him from dictating to his son his ideas on the cleavage of trees by the electric spark.

"In men whose life is in their intellect, the obstructions of the physiological functions have but a feeble effect on the brain; this was, nevertheless, the last time that his thoughts manifested themselves to those around him. The next morning his friends found him sinking, but calm; a few hours and he was no more.

"Thus terminated this life so filled with labor of which science had the best and noblest portion. He died firmly believing in the infinite progression of physical philosophy, and confident in the bright future of experimental science, which he regarded as the anchor of safety and truth.

"For him is accomplished that terrible phenomenon whose name is death; but, like all strong men who dare to look beyond, he was prepared."

APPENDIX TO THE BIOGRAPHIC NOTICE OF PELTIER—SCIENTIFIC NOTICE.

[TRANSLATED FOR THE SMITHSONIAN INSTITUTION, BY C. A. ALEXANDER.*]

I.—MICROSCOPIC RESEARCHES.

We owe to Peltier observations on certain new microscopic animals. We will cite among others his observations on a vorticella which, by its form, closely approximates to that which Muller has called citrine, and, in its interior constitution, resembles the vorticella or umbel of Roësel. We will also advert to his observations on a new species of floscularia. We shall not, however, dwell on this class of researches. Peltier, in fact, had never devoted himself to the use of the microscope in order to discover new individuals; microscopy was for him but a means of study for arriving at a more thorough knowledge of physiology.

Effects of inanition on the infusoria.—Microscopic animals have, in general, a very simple structure; still they are often too complex to admit of an advantageous study in them of the different phenomena of organized bodies. Peltier conceived the ingenious idea of employing inanition in order to rid these animals of all superfluous matter, and to reduce them to their most simple expression. The following is the method which should be taken: † On a glass plate let a circle of tin be glued, and in the centre of this circle place the drop of water which is proposed to be examined; on the tin circle spread a thin coat of oil, with the exception of a section of a few millimetres.‡ This arrangement has several advantages; in the first place the thickness of the tin does not permit the drop of water to extend itself by capillarity as far as the edges, and entirely to flow away as ordinarily happens; the liquid remains at rest at the centre of the circle which circumscribes without touching it; moreover, the circle of oil delays evaporation. If we closed it entirely, there ensues, in 24 hours, asphyxia of a great part of the animalcules; while, by leaving a small space without oil, the drop of water may be preserved from three to eight days, according to the temperature and hygrometricity of the air. The animals thus preserved in a drop of water will have soon exhausted all the nutritive matter which it contained, and a succession of very remarkable effects produced by inanition is progressively brought to view.

In proportion as the drop of water becomes impoverished, most of the animals give more development and extension to their organs of contact; frequently new vesicles are developed on the sides of the corona of the vorticellæ, and around the cephalic projections of the rostrated cyclida the protées become transformed; and the more as the drop of water has been longer kept. It seems, in a word, that aliment no longer reaching the organism in sufficient quantity, this organism forms a sort of hernia of all its parts in order thus to reach it. At the same time that the appendages are developed, the body of the animal is gradually reduced to its elements. Peltier witnessed, for instance, in the vorticella above spoken of, the following phenomena: at the end of five or six days of inanition, the agglomerations attached to the exterior membrane of the animal diminish in number; when the vorticella is wholly enfee-

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* *Notice sur la vie et les travaux scientifiques de J. C. A. Peltier, par son fils.* Paris, 1847.

† *Annales des Sciences Naturelles*, February, 1838. Vol. 9, p. 89.

‡ The French measures used in this article correspond to the English as follows: the millimetre = .03937 inch.; milligram = .0154 grain; decimetre = 3.937 inches; centimetre = 0.39371 inch.; metre = 1.093633 yard.

bled, it has lost them all; it is then no more than a very thin and diaphanous membrane in which no organ is any longer perceptible. In this state, all movement has ceased; the particles of the membrane itself become disintegrated and the vorticella dissolves globule by globule; at other times a rupture takes place in a part of the membrane, the internal liquid escapes, and the animal has ceased to live.

Reproduction of infusoria.—It is known that among the infusoria, properly so called, reproduction takes place commonly by fissiparity; they continue separating into two parts, and thus form new beings. This mode of reproduction is so rapid that a single paramecia observed for some days divided itself four times in 24 or 30 hours, producing thousands of new creatures in the lapse of a few days. This generation only proceeds with activity when an exuberant nourishment is supplied to these animals. Peltier, however, produced by inanition, in a great number of animalcules, an effect analogous to that which results from an excess of nutrition.

There are species which possess a contractile dorsal vessel, in which we can follow the progress of the nutritive liquid; such are the digitated naiadæ. If these animals be subjected to inanition, we shall see, in proportion as the liquid is impoverished, a contraction of the dorsal vessel, which is less stretched out, and stops where the liquid ceases to arrive, because it has been absorbed by the anterior parts. When this movement is thus arrested, there will be seen to be formed, at the middle of the body, at the point where the nutritive liquid ceases to arrive, and where the contraction of the vessel stops, two large absorbent vesicles, which imbibe for the behoof of the posterior part. As soon as these vesicles enter into action the second half of the dorsal vessel resumes its contractile movements; these contractions, be it understood, take their origin in the new vesicles, and have no communication with the anterior part nor any synchronism with its movement. In front of these vesicles, a constriction is presently formed, which increases by degrees, and which ends by completely separating the two portions, which then constitute two distinct individuals.

The anterior portion, better organized and better supplied with appendages for alimentation, has more vivacity, more energy, than the other. If we succeed in preserving the drop of water seven or eight days, the nutritive matter diminishing more and more, there occurs for the two halves that which occurred for the entire animal: the quantity absorbed by the anterior parts is no longer sufficient for the total alimentation, and the posterior part is left in a state of complete inanition. It was thus that Peltier obtained in one instance a new separation into two of each of the two former halves, and eventually a new separation of the two quarters proceeding from the anterior half; the two separated parts of the posterior half had ceased to live before he could effect a new separation. The result, therefore, was the formation of six individuals proceeding from the separation of the parts which the dorsal vessel could no longer supply with nourishment.

Peltier has verified the same fact with regard to the pustulous kerones; having subjected these animals to protracted inanition, he perceived that, in the middle of the body, an indentment was formed which went on constantly increasing, and finally separated the animal into two parts; the anterior half continued to live, it appeared even to acquire new energy by the loss of the posterior half of its substance, while this latter often died at once, though sometimes it remained alive for a certain interval. In every case, the instant of the death of the individual restored to liberty and their own spontaneity the rest of the globules which happened to be in its interior. Peltier observed also similar peculiarities in the kidney-shaped cyclidæ.

M. Dujardin had inferred from his researches that certain animals might be produced by means of lobes of their substance abandoned by them on the bodies to which they attach themselves. Peltier has confirmed this idea by

numerous observations on the common and the scutelliform arcellæ. The mother-arcella begins by extending, under the form of a large disk, a portion of her membrane. This portion of membrane is attached to the horny shell by prolongations at regular intervals. It is at first perfectly smooth, of great transparence, and contains no other substance; when its formation is finished, a portion of the glutinous matter of the mother flows upon it. In one instance Peltier saw this glutinous substance flow too abundantly on the new membrane and leave but about a sixth of it for the mother; the current now stopped, then retrograded, and an inverse current was established for the benefit of the primitive arcella. An instant afterwards, when the original current had been re-established and again conveyed the vivifying matter on the young disk, it once more surpassed the bounds and left the arcella too much impoverished. It was not until after five or six oscillations of this sort, the amplitude of the flow diminishing each time, that a due distribution was effected and the intercommunication ceased. The vascular filament which united the two arcellæ gradually became thinner, then entirely separated, and two minutes afterwards the two distinct animalcules withdrew one from the other, both thrusting out their arms and performing their customary digitations. This mode of generation is certainly very remarkable; we here see the half of a living creature flowing outwardly and forming with this excreted moiety an animal in all respects similar to the moiety remaining.

Peltier observed, in 1830, another example of generation by an efflux of substance still more curious than the former, for here the efflux was not spontaneous. He had placed between two glasses, under the microscope, a drop of water in which there was a very large specimen of Muller's vesicular leucophra; in slightly compressing the two glasses, the external membrane was broken and perhaps a hundred of the globules which fill the animal were extruded. Many of these were scattered about in being projected by the pressure, but others clung together in a space of small extent. The former remained apart, and nothing was remarked in them but the tremulous motion of light bodies. The globules of the agglomerated portion, on the contrary, gradually drew closer together, grouped themselves, and finally, at the end of an hour, formed a sphere whose contour, of a brilliancy inclined to nacreous, indicated the formation of a membrane. At the end of two hours there was perceivable in the circumference the reflection of the liquid in motion, and shortly afterwards the oscillations of very fine cilia. The leucophra was now complete and presently revolved upon itself, then spontaneously changed its place and traversed the drop of water. Thus this little animal was produced externally by the agglomeration of the substance which had been made to issue mechanically from the mother.

Transformations of zoosperms.—Peltier had followed with much attention the successive transformations of zoosperms, especially those of the frog.* He showed first that the spermatic liquor expressed from the testicles contains, in winter, only simple spherical globules. As adolescence approaches, and the season of copulation, these globules become covered with black points and small projections, which latter speedily elongate, forming each a cone, the point of which appears filamentous and soon undergoes much enlargement; at the same time the filaments which terminate these cones grow more and more distinct and present the appearance of a tuft of hairs. The cones thus terminated by filaments consist of small masses of zoosperms, attached by the head to the black points of the central globule, and free in their caudal extremity.

As long as these globules swim in their natural liquor, no movement is perceived; but if there be mixed with it blood from the neighboring veins and arteries, the point of the tufted cone partially opens and some of the filaments which terminate it commence oscillating with their terminal parts. If blood

* *Journal l'Institut*, 1838, t. vi, p. 132. Idem., 1840, t. viii, p. 392.

taken from another organ than the testicles be added, the movement is communicated to a still greater number, the expansion of the tufts increases, the oscillation extends to half the length of the fibrils, and the posterior portion of the zoosperms may then be perfectly recognized; if a still more heterogeneous liquid be added, such as river or pond water, the movement becomes general and the whole body of the filament oscillates. After a few instants, some of these filaments are seen to detach themselves from the primitive nucleus; presently all successively quit it, become so many complete zoosperms, and leave the parent globule covered with brownish points where they had been attached.

Once become free, the zoosperms undergo new transformations; their anterior part bends in an arch more or less elongated; this arch, by closing, constitutes a ring in some and an oblong mesh in others. A little later their anterior part has assumed the shape of a cupel, fringed with vibratile cilia; but before entering into this last state, these zoosperms have passed through intermediate forms, giving them the appearance of different animalcules, by which circumstance observers have been often deceived. Such, according to the researches of Peltier, are the successive transformations presented by the zoosperms of the frog.

Structure and contraction of the muscles.—Peltier also occupied himself with the structure of the muscles and the phenomenon of contraction. He even availed himself of several different methods, that he might study them with greater profit. Sometimes he simply examined the muscular fibres with the microscope, sometimes he proceeded by crushing them on the porte-object glass; again, he unravelled them by means of the finest needles. He often operated also on muscles desiccated by heat, for this process also yields good results. He studied likewise the structure of the muscles in certain microscopic animals which have muscles in a rudimentary state, and composed of one, two, or three fibrils. In a word, he had employed all the means which science could furnish him, and the following are the results to which he was conducted:*

The muscles are composed of distinct cylinders, of a diameter of from $\frac{1}{30}$ to $\frac{1}{50}$ of a millimetre. Seen with the microscope, these cylinders seem divided by rather transparent longitudinal lines and by darker transverse lines. This causes them to appear somewhat like an assemblage of small graduated scales of a perfect regularity. The cylinders in question are formed of fibrils in juxtaposition, while the fibrils themselves are constituted by a tube filled with minute grains, the diameter of which varies, in different animals, from $\frac{1}{800}$ to $\frac{1}{1200}$ of a millimetre.

In studying these fibrils it is seen that the globules are ranged in succession one above the other in their sheaths, that they touch and press one another, while the globules situated in the same transverse range, and pertaining each to a different tube, are separated by a double membrane extremely transparent. When a ray of light traverses a muscular fibre, diffraction takes place quite around each globule, except at the point of contact of the globules superposed in the same sheath. It thus forms an image unequally illuminated, being less so at the part in contact than in the rest of the outline of the globules. Hence it results that the transverse lines which connect all these obscure points are darker than the longitudinal lines; and from this we see in what consisted the error of the physiologists who thought that these transverse fibres were formed by nervous filaments, wound in a helix around the muscular fibre.

The globules of the elementary fibrils are strongly adherent to one another and to their sheaths, for it is very rare to find portions of the latter devoid of their globules.

When certain microscopic animals are deprived of life by long inanition, the whole contractile membrane is seen to be formed of aligned globules. In this case also the different phases of the phenomenon of contraction may be followed with facility. It will be seen that the arrangement in zigzag has here replaced

* *Annales des Sciences Naturelles*, 2d series. Zoology, vol. ix, p. 89.

the arrangement in a straight serial line. The sheath is shortened in obeying this new arrangement; it folds slightly on itself, like the finger of a glove whose two ends are pressed nearer together. The elasticity of the sheath, however, renders this corrugation very difficult to be perceived.

On the structure of the nerves.—When Charles Bell had published his treatise on the distinction of the nerves of the face into nerves of movement and nerves of sensation, Magendie proceeded to inquire whether there were not something analogous in the rachidian nerves, and soon thereafter proved, in effect, that the posterior roots of these nerves presided over the sensibility, while the anterior roots governed the power of movement. It was natural to suppose that these two sorts of nerves had a different structure and constitution. Peltier applied himself to this interesting question, and we will recall the principal facts which he made public.*

The nerves of sensibility have not a texture similar to those of movement, and moreover each of them in particular varies according to the proximity of its insertion in the organ or of its exit from the cerebro-spinal centre.

In removing further from the cerebro-spinal centre, the cellular tissue of the nerves increases and becomes more resistant; it circumscribes more and more the medullary pulp, and in the end forms for it distinct sheaths. At first there are but small portions of this pulp thus circumscribed and enclosed in the sheaths; the rest surrounds them and fills the interstices which separate them. The number of these sheaths continually increases, and the free pulp diminishes in the same proportion. The nearer we approach the termination of the nerves, the more glutinous does this pulp become and the greater the cohesiveness it acquires.

The nerves which are ramified in the muscles are formed of tubes of about $\frac{1}{150}$ of a millimetre; the membrane which constitutes them is of little consistency; at the least pressure it yields unequally, and the medullary substance which it contains forms varicosities. The nearer the periphery, the fewer the varicosities, because the sheath becomes more resistant and the pulp diminishes. These tubes or nervous fibrils, however, always preserve a considerable part of their globules in line, whatever the pressure exerted on them. Towards their insertion they are finer, more regular, and more numerous; the globules of the pulp are there better aligned, their position is fixed, pressure no longer displaces them, and these nervous fibrils might be readily confounded with the muscular fibrils, if the transverse lines found in the latter were not wanting.

Arrived at the muscle to which it is destined, the nervous filament sends forth, at variable distances, bundles of elementary fibrils which have become extremely thin. They are in diameter about $\frac{1}{800}$ of a millimetre, and are only formed of a series of contiguous globules; scarcely does pressure any longer discover a little free pulp in their interstices. These bundles of nervous fibrils are dispersed over all the adjacent muscular fibrils, in the midst of which they successively disappear, without our being able to see how they terminate. It might almost be believed that the muscular fibril is, as regards a part of its substance, but a continuation of the nervous fibril.

The nerves of sensibility have a different constitution from the preceding. They contain less of the nervous pulp in a state of semi-fluidity; on compression no varicosities are produced; their fibrils are more tenuous; they have, at first, a diameter of from $\frac{1}{300}$ to $\frac{1}{500}$ of a millimetre, but towards the organ in which they are inserted of not more than from $\frac{1}{1000}$ to $\frac{1}{1100}$ of a millimetre. Their globules are much smaller, being not larger than about $\frac{1}{1200}$ of a millimetre; they are regularly aligned, and pressure does not displace them. These fibrils often cross one another in their progress. A certain number of them, united in little bandlets, form, in crossing, lozenges elongated at the point of their intersection; these bands are strongly adherent, and cannot be detached but by tearing them.

* *Journal l'Institut*, 1839, t. vii, p. 113.

II.—STATIC ELECTRICITY.

Difference of static and dynamic electricity.—Electricity may present itself in two distinct conditions; it may be in repose or in movement. In the first case it is said to be in a static, in the second in a dynamic, state. The phenomena which it produces in these two cases are very different.

This distinction is to be found in all treatises on physics; but no author has insisted so much as Peltier on the difference—on the almost constant opposition, indeed, which exists between the phenomena produced by static electricity and those produced by dynamic electricity; by electricity in repose or in movement.*

Static electricity, says Peltier, is double; each of its forms is collected, controlled, and maintained separately. They do not become manifest except in this state of insulation and of separation. They may be preserved thus separated by means of insulating bodies, and their action then is as enduring as their insulation. Static electricity is accumulated at the surface; its effects reduce themselves to the phenomena of attraction and repulsion. When two bodies are charged with the same electricity they separate from one another; when charged with contrary electricities they approach one another, &c.

Dynamic electricity exhibits constantly opposite properties. It is not double; it cannot be collected, coerced, or preserved. To have a constant dynamic effect, it is necessary that the cause itself should act in a constant manner. It seeks not the surface; on the contrary, it is propagated through the interior of bodies and has relations only with ponderable quantities of matter. Like currents attract one another; unlike currents repel one another. Finally, dynamic electricity has an extreme diversity of action; it alters the temperature of bodies, vaporizes or decomposes them, magnetizes iron and steel, causes deviation of the magnetic needle, &c.

The two orders of phenomena, static and dynamic, are rarely coexistent; it is only when the current has ceased, through a forcible interruption, that a static effect appears; so, too, it is only when free course is given to the cause of the static effect that the dynamic effect is reproduced; but the two effects never are and never can be simultaneously produced by the same portion of electricity. When these two effects make their appearance at the same time, as happens in the case of an insufficient conductor, the portion of electricity which passes produces only dynamic effects, and the portion of electricity arrested produces only static effects.

Relation of static and dynamic actions.—Peltier had measured the extent of the electric phenomena, both static and dynamic, which may be produced by the oxidation of a milligram of zinc. By causing the electricity produced by a given quantity of substance to pass successively from the dynamic to the static condition, and from the static to the dynamic, he found that the quantity of substance necessary, in order to produce the dynamic effect of one degree of a good multiplier, may yield a static effect of 7,069 degrees of the electrometer of his own invention, and, moreover, that the static effects which it produces are as the square of its dynamic effects; hence the quantity of oxidized substance which doubles a dynamic effect, quadruples the static effect which springs from it.†

Electric capacity of the metals.—Peltier first demonstrated that the metals have not equal capacities for receiving the same static electricity from a constant source; thus, zinc takes and retains more positive than negative electricity, while the contrary takes place with copper. Gold is likewise more apt than silver and platina to become charged with positive electricity.‡

* See *Annales de Chimie et de Physique*, 1838, t. 67, p. 422: a memoir of Peltier on the quantities of dynamic and static action produced by the oxidation of a milligramme of zinc. See also the article Galvanism of the *Dictionnaire Univers. d'Histoire Naturelle.*

† *Annales de Chimie et de Physique*, 1838; memoir before cited.

‡ *Comptes-rendus de l'Academie des Sciences*, 1835, t. 1, pp. 360 and 470.

After having sufficiently verified this fact, Peltier sought to find whether it was the consequence of a special force or the result of a permanent electric state, and he ascertained that in their natural state, or that of equilibrium, bodies possess different quantities of static electricity, and that consequently the proximity of a metal which, like platina for instance, is negative in its natural state of equilibrium, influences the neighboring bodies, rendering them more positive, and, in consequence, more apt to receive and retain positive electricity. From this it results that two condensing plates, the one of gold, the other of platina, influence one another; the platina renders the gold more apt to receive and retain positive electricity, and the gold renders the platina more apt to receive from it negative electricity. If these two plates be placed in contact they take reciprocally that electricity for which they have most aptitude.

We must not confound this peculiar property of the metals with the electromotive force of Volta. Contact is here of no account, for the same results are obtained without contact, only in this case the results are somewhat lessened by the distance.

After having verified these facts, Peltier expressed them in the most general manner, by saying that the metals have different capacities for collecting the same static electricity from a constant source. But it was impossible for him to arrive at the cause of this difference. Since that time, the researches of M. de la Rive, and especially those of M. Edmond Becquerel, would seem to have sufficiently elucidated the problem. These two savants have demonstrated in effect that the metals least liable to be tarnished are yet, in reality, oxidized in the open air; but very slowly and very slightly, which had theretofore prevented the physicists from perceiving it. The quantity of platina oxidized is unquestionably very minute, but the experiments of Faraday, of Peltier, and of Becquerel have proved that it needs but the oxidation of an almost imperceptible quantity of metal to produce considerable quantities of static electricity; if, therefore, platina is always naturally negative in relation to gold, it is because it oxidizes to a greater degree; if it is also negative in relation to zinc, this is referable to the fact that the zinc employed is always covered with a coat of oxide which preserves the metal from all ulterior alteration.

Modifications in the torsion balance.—For a long time there was nothing available for the purpose of indicating the tension of static electricity, except the gold-leaf electrometer and the torsion balance. The former instrument possesses great sensibility, but unfortunately does not afford a measure; the latter, on the contrary, gives exact measures, but has not the sensibility requisite for delicate experiments; it has besides some serious defects. Peltier adapted to the torsion balance modifications which eliminated these defects, and designed, besides, an electrometer which unites the precision and measurement of the torsion balance with the sensibility of the best gold-leaf electroscopes. We shall speak in succession of the torsion balance, as modified by Peltier, and of his electrometer.

The torsion balance, as it was employed by Coulomb, had the inconvenience of not maintaining in electric equilibrium the two balls between which the electricity under experiment is distributed. When one of the two loses more than the other, whether by reason of its own asperities or that of the neighboring bodies, the humidity of the air and the imperfect insulation of the supports which is the consequence thereof, or through whatsoever other accidental cause, there results an inequality of action, of which the resultant is no longer the expression of the repulsive quantities alone; for as soon as the inequality of charge supervenes, the action becomes complicated from the repulsion of the similar electricities, and from the attraction produced by the excess of one of the balls over the contrary electricity of the other ball, which the former developes by influence.

With a view to avoid these causes of error, Conlomb took infinite precautions

to assure himself that during the whole time of the experiment the total loss should be very small, and consequently the difference still smaller. When the experiment, however, lasts a long time, and in damp weather, we cannot neglect this difference in the electric state of the balls, since it involves a considerable one in the results. On the other hand, there are many experiments in which it is proposed to measure the successive addition or subtraction of the electric forces, which cannot be done with an instrument of which the active parts are insulated one from the other.

Peltier corrected these defects by applying to the torsion balance two important modifications. In the first place he established a permanent communication between the movable disk and the fixed ball; secondly, he soldered this last to a metallic rod which projects laterally, and which, after having left the ball, is bent vertically in order to receive the condensing plates or any other apparatus. The following is briefly a description of this instrument:

The torsion balance as modified by Peltier presents at its upper part a micrometer, like that of Conlomb's balance. A cocoon thread, devoid of torsion, is attached to the windlass of this micrometer by its upper extremity, and bears at its lower end a metallic needle, terminated on one hand by a proof plane, and on the other by a balance weight of gum-lac. The needle has on its lower face, and in the line of prolongation of the cocoon thread, a point of platina descending vertically. This point is immersed in a capsule of glass, into which has been previously introduced diluted sulphuric acid. The capsule is carefully surrounded with resin, and rests on a plate of copper. This plate may be raised or lower by means of a bent lever, whose leg is situated without and passes underneath the footstand of the instrument. The fixed ball, as has been already said, is soldered to a copper rod which projects laterally through the glass case which covers the instrument, and then rises vertically, so as to receive the condensing plates or other apparatus. A fine wire proceeds from the rod which supports the fixed ball, and directs itself towards the capsule filled with sulphuric acid; having reached this capsule the wire is bent at a right angle, and descends into the acid. When the instrument is to be used the capsule is elevated by means of the bent lever; when the experiment is finished it is lowered, and the point of platina and the wire are no longer immersed in the acid.

Peltier placed, moreover, two graduated circles, one on the footstand of the instrument, and the other on the upper plane of the casing. These two circles correspond; consequently, if the visual ray is made to pass by the same degrees in the two circles, the deviation of the needle may be read without the possibility of error.

Those who are a little conversant with electricity will readily comprehend the object and advantages of the arrangements here indicated. By means of these modifications, in effect, the tension remains perfectly equal between the fixed ball and the proof plane, even when the experiments last some time, or when the electricity which is to be measured is either augmented or diminished.

Electrometer.—We pass now to a description of the electrometer of Peltier.* On a socle or footstand, three decimetres in diameter, is pasted a dial-plate of pasteboard, graduated to 360 degrees; at five centimetres above the centre of this dial is the extremity of a rod of copper having a section of seven millimetres. This rod is slightly curved, and bends back almost at a right angle when it arrives above the zero. It then penetrates vertically into the footstand from which it is insulated by resin; it is there again bent round so as to proceed laterally; then, at a distance of a few centimetres, it rises vertically to receive the plates of Volta or any other apparatus. On the inner extremity of this rod, just above the centre of the dial, is soldered a small plate of tempered steel, polished and slightly concave.

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* *Annales de Chimie et de Physique*, t. 62, p. 422.

This concave surface is destined to receive the pivot of a needle formed of a very fine copper wire. The needle is a decimetre in length, and is thus equal to the radius of the dial. Its pivot is soldered to its posterior part; consequently it must be maintained in equilibrium by a small counterpoise of gum-lac. The pivot is of tempered steel, and terminated by as fine a point as possible. The copper wire which forms the needle is slightly curved, in order that its greatest portion in length may be placed in contact with the rod, and receive from it a greater influence. To give a direction to it we place at the centre, forming one body with this rod and with the pivot, a very small wire of tempered steel, very feebly magnetized, to which is imparted only the quantity of magnetism rigorously necessary to draw the large needle near the horizontal rod.

To obtain the maximum of sensibility, it is necessary that the movable needle should not be of steel; for however little magnetism might be given it or be received by it, whether from its position in the magnetic meridian, or through oxidation, it would act on the particles of iron contained in all the coppers of commerce, and thus alter the great sensibility of this instrument.

The electrometer is covered with a glass cylinder, the upper flat surface of which presents another graduated circle, corresponding to the lower circle. In this way the visual ray passes by the same degrees in the two circles, and thus no error of parallax is to be apprehended.

Peltier had further added a movable armature. This was a plate of copper, of the length of the needle, and placed at the same height. It was worked by means of a horizontal lever, situated below the foot-stand. This armature considerably augmented the sensibility of the instrument; unfortunately it somewhat embarrassed the phenomena, and the instrument lost in point of exactness; hence Peltier seldom employed it.

The manner of using this electrometer is very simple. The apparatus is placed in the magnetic meridian, so that the needle may touch lightly the fixed rod. The instrument being thus adjusted, we touch the exterior ball or the plate with the body charged with the electricity which we wish to measure, and immediately the needle deviates by a certain number of degrees, which may be read on the dial. Thus we have results perfectly comparable; the fixed rod and the movable needle, always in metallic contact, maintain infallibly an equilibrium of electricity.

However light the indicating needles, their weight occasions a slight friction on the concave plane which supports the pivot. This friction gives to the instrument a small resistance which prevents it from obeying at the instant, when very weak quantities of electricity are either added or withdrawn. To overcome this resistance, it is sufficient in general to strike lightly on the table which supports the electrometer.

For those who have an electrometer, but no torsion balance, it is necessary that the electrometer should be capable of being transformed at will to a torsion balance. Peltier added, therefore, to his electrometer different pieces, with a view of rendering this transformation possible and easy. The pieces are the following: 1°. A gallows formed of a foot of copper or ivory, screwed in the pedestal; of a vertical staff of glass, 25 centimetres in length, and of a horizontal bridge of copper, the free extremity of which corresponds exactly to the centre of the dial-plate. 2°. An apparatus destined to carry the wire and possessing two very distinct movements—one horizontal and circular, the other vertical and rectilinear. 3°. A silver wire of the utmost fineness, terminated at its lower extremity by a small cylinder of gum-lac, having beneath it two small copper hooks designed to carry the needle.

In order to transform the electrometer into a torsion balance, it is enough to lower the wire by means of the vertical and rectilinear movement above indicated, to seize the needle with the two hooks, and again sufficiently raise the whole; by this means, in effect, the indicating needle, instead of being sup-

ported by the point of the pivot resting in the steel cup, is suspended by the silver wire, without being, however, in metallic contact with it, since it is separated from it by the small cylinder of gum-lac.

When these changes have been made, the electrometer has become a torsion balance; only, if we wish to use it as such, it is necessary to withdraw from the indicating needle the small wire of magnetized steel, or still better, to have a spare needle for exchange. There remains but one other condition to fulfil in order that the torsion balance should be completely prepared; that is, to establish the communication between the needle and the capsule, though with the exclusion of all friction.

In the torsion balances, Peltier employs acidulated water, because the point which descends into the liquid is of platina; but here, as the point is a pivot of steel, even pure water cannot be used, much less acidulated water, for the pivot would be soon oxidized. Doubtless this communication might be established by means of mercury poured into the little cup; but this metal is too resistant, and detracts much from the sensibility of the instrument. There is, besides, an inconvenience in using it; its resistance prevents the needle from placing itself perfectly at its centre of gravity; whence it results that the suspending wire, instead of being vertical, has a slight inclination, and consequently the needle has a tendency to fall to one side. The liquid which suits best is a solution of potash, for this preserves unimpaired the polish of iron and steel, and suffices as a conductor for the electricity of tension between two bodies in such close proximity as the steel cup and its pivot.

At first Peltier had given to his electrometer dimensions somewhat large. It was then, in effect, a cabinet instrument; but afterwards, when he occupied himself with meteorology, he perceived the necessity of reducing these dimensions, in order to render it more manageable and portable; he therefore constructed an electrometer of small size and very nearly conformed to the proportions of an ordinary electroscope. This instrument has been also adjusted to the use for which it was to serve. The fixed rod no longer communicates outside laterally and by the foot-stand; its interior extremity, that which is above the centre of the dial, is curved from below upwards, and issues from the casing by its upper wall; it is then prolonged vertically for two decimetres, and is surmounted by a hollow metallic ball, eight centimetres in diameter. This is the atmospheric electrometer of Peltier.

We must not quit this subject without mentioning that these electrometers all require that a table giving the ratio of the forces to the arc of deviation should be constructed for each of them. It is the same, in effect, with electrometers as with galvanometers: their angular deviation is not proportional to the forces.

III.—Dynamic electricity.—Voltaic pile.

Of the pile of Volta and the theory of contact.—The most usual source of dynamic electricity is the pile of Volta. This is one of the most admirable instruments with which the genius of man has enriched science, and numerous physicists have occupied themselves with its theory.

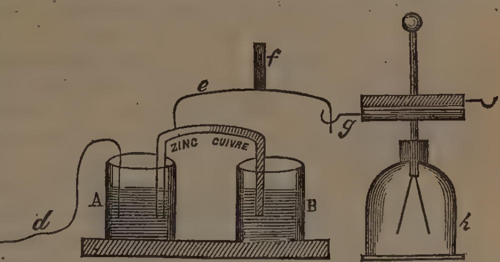
Volta supposed that at the contact of two heterogeneous metals, there is a force which constantly decomposes their natural electricity; that this force projects on the one side positive and on the other negative electricity; that the interposed liquid serves only as a conductor to allow the recombination in the neutral fluid of the two opposite currents. It was this decomposing power placed at the contact of the metals that he called the electro-motive force. This theory has received the name of the theory of contact.

According to this theory, the liquid acts but as a conductor; an experiment of Davy's, however, soon evinced the inexactness of this assertion. After having constructed a battery of cups, of copper and iron, Davy first poured pure

water in the jars; the iron became positively electrified, and was oxidized; the copper, on the contrary, was negatively electrified, and disengaged hydrogen. In a second experiment, in place of pure water, Davy poured into the jars sulphur of potassium; immediately the iron became negative, and disengaged hydrogen, while the copper became positive, and was oxidized. The poles of the pile were therefore inverted, and the direction of the current had been changed with the nature of the liquid body interposed.

Experiment of Peltier, proving that there is no electro-motive force on the contact of the two metals.—We are also indebted to Peltier for an experiment which completely overthrows the theory of Volta, and which proves, in the most positive manner, that there is not an electro-motive force at the contact of the two elements of zinc and copper. As this experiment is of the highest importance for the theory of the pile, we shall report it with some details.*

We plunge in two separate vases, well insulated and filled with the same liquid, the extremities of a pair, zinc and copper. We first immerse the end of a wire of platina *d* in the vase A which has received the zinc, and the other end of the wire communicates with the ground. By means of another wire of platina *e*, which is kept insulated by a sleeve of gum-lac *f*, we successively put in communication the zinc, the copper, and the liquid of the vase B which has received the copper, with one of the condensing plates *g* of an electrometer *h*. Agreeably to this arrangement, the liquid cannot possess free electricity, since it communicates with the ground, and the zinc can as little possess it, since the electro-motive force, according to the theory, results from the contact of the zinc and copper. It is not thus that the distribution is effected: the liquid of the vase A is neutral, but the zinc, the copper, and the liquid B, are negative in the same degree. We place now the end *d* of the platina wire, communicating with the ground, in the vase B, and interrogate, in the same manner, by means of the insulated platina wire *e*, the copper, the zinc, and the liquid of the vase A, which is then insulated. The liquid of B is necessarily neutral, as well as the copper which is plunged in it, but the same is the case with the zinc, which is also neutral; the water of the vase A alone is positive.



This experiment demonstrates that the electricity of a zinc and copper pair is not produced, as Volta thought, by the contact of the two metals; it proves, moreover, that it is produced on the contact between the acidulated liquid A and the portion of zinc which is immersed. There could be, then, no longer any doubt about the error of Volta; for, on his theory, the zinc and copper would be in different electric states, and this experiment proves, on the contrary, that they are both one and the other in the same state.

Since the electricity proceeds, not from the contact between the two heterogeneous metals, and is produced on the surface of the zinc moistened by the acidulated liquid—on the surface which the acidulated liquid attacks chemically—everything tends to the conclusion that it is the chemical action itself which produces the electricity. This opinion, proposed for the first time in 1801 by Parrot, supported by the experiments of Febroni, Wollaston, Faraday, and Becquerel, was again considered, in 1828, by M. de la Rive, to whom pertains the honor of having first made known, in a clear and satisfactory manner, the true theory of the pile.

Chemical theory of the pile, by de la Rive.—According to this distinguished

* Peltier, *Essai sur la co-ordination des causes des phenomènas électriques.*—Memoir of foreign savants of the Academy of Sciences of Brussels, vol. 19, p. 34 of the memoir, note.

physicist, the origin of the electricity of the pile of Volta is the chemical action which takes place between the acidulated liquid and the zinc. The negative electricity diffuses itself over the metal attacked, the positive electricity diffuses itself in the acidulated liquid. These electricities are afterwards neutralized, each on its side, with the opposite electricities of the adjacent pairs, and the same fact reappears as far as the two extremities of the pile, which alone are in possession of free electricity. In a well-constructed pile, according to M. de la Rive, there is a neutralization of all the intermediate electricities; all the negative portions are neutralized by equal positive portions, proceeding from the pairs in juxtaposition; there are none free but the electricities of the two extreme elements, and these polar electricities have, in order to become neutralized, only the arc interposed between them or a return by the pile.

From this it is evident that the quantity of electricity found at the poles of a battery is independent of the number of pairs, and that the number of pairs must only augment the difficulty of recomposition backwards; that is to say, must augment the tendency of the electricity to combine forwards. But in physics it is not enough to advance a theory more or less satisfactory: it is necessary to demonstrate it; it is necessary to prove the reality by numerous and positive experiments which can leave no doubt or uncertainty; it is necessary, in a word, to anticipate all objections and answer them in advance. This is what Peltier has done.*

Summary of Peltier's researches on the Voltaic pile.—According to Peltier, in a current there are two very different things to be distinguished: the quantity and the intensity. The quantity is the number of electric perturbations which traverse a conductor in a unit of time. The intensity is the power which a current possesses of overcoming the resistance of the conductors presented to it.

Peltier, to whom we are indebted for having clearly established this distinction, has demonstrated by multiplied experiments that in a battery the quantity of electricity produced is in a ratio with the number of molecules pertaining to one and the same surface, and undergoing a change in their equilibrium; but that, in the estimate of the quantity of electricity which passes by the conductors in the state of a current, it is necessary to regard the resistance of these conductors, because these resistances almost always cause a portion of the quantity of electricity produced to be in return neutralized. He has shown that when the resistance of the conductors is null, the quantity of electricity which passes by the closed circuit is proportional to the quantity of molecules attacked on the same surface.

He has proved that when a battery is well constructed and the circuit without resistance, the entire pile gives no more electricity than a single one of its pairs; consequently that when it is desirable to have a current of quantity, it is necessary to use a battery with pairs of large dimensions.

It was generally thought that in a battery, when one pair was smaller than the others, this small pair decided the quantity of the whole current. Peltier proved that this opinion was not wholly exact. No doubt this small pair diminishes the quantity of the current. In consequence of its resistance, which is greater by reason of its very littleness, it forces a portion of the electricity which reaches it to recombine behind it, but it gives passage as a simple conductor to the rest.

By means of positive experiments, Peltier has demonstrated that the intensity of a current, that is to say, the power it possesses of overcoming obstacles, is only due to the greater obstacles situated behind to prevent retrogradation of the two polar electricities by the battery. Now, these obstacles may be of two sorts: they may proceed from the reduplication in a battery of the same pairs, or else from a more profound alteration in the state of equilibrium of the molecules. In the first case, the intensity is proportional to the number of pairs; in the second, it depends on the power of action of the disturbing substance.

* See *Annales de Chimie et de Physique*, 1836, t. 63, p. 245: the note of Peltier entitled "Definition of the words electric quantity and intensity, drawn from direct experiments."

Peltier has also proved that a current endowed with a great intensity is identical with a current which possesses but a feeble one, and that these currents of great and feeble intensity produce the same effects on bodies when they traverse them in equal quantities. He has established, by two series of new experiments, the one dynamic, the other static, that in a battery well constructed there is a neutralization of all the intermediate electricities; that all the negative portions are neutralized by equal positive portions proceeding from the pairs in front of them, and that there are no free electricities but those of the extreme elements, which, to become neutralized, have only the arc interposed between them, or a return by the battery. Finally, he proved that it was always by its quantity that a current acted, but on the condition of being accompanied by a sufficient intensity; for, without this intensity, the current could not pass in suitable quantity to produce action; the resistance of the conductors would oppose itself to that action.

We proceed now to indicate the chief experiments by means of which Peltier has demonstrated the principles above stated. These experiments are almost all derived from the memoir of Peltier, already cited, on the electric quantity and intensity.

Experiments of Peltier relative to the quantity and intensity of a current.—If we take a voltaic pair consisting of two fine wires, zinc and copper, immerse it in common water, and complete the circuit by a copper wire of the length of 300 metres, there is a continuous current in this closed circuit. If this wire be presented above a magnetized needle, the needle will not be deflected from its position of equilibrium in the magnetic meridian; the action of the current will not be powerful enough to overcome the influence of the terrestrial magnetism. But if this needle be surrounded with 100 or 200 coils of the long wire, there will be at once a notable deviation; if the number of coils be increased to 2,000, the deviation will extend as far as 60 degrees.

In this experiment, the primitive current has not been changed or altered. We have only produced a factitious quantity by conducting it 2,000 times around a magnetized needle, so that it may act as the primitive quantity multiplied by 2,000. It is very evident in this experiment that it is by the *quantity* that the power of action has been enhanced, and not by some other modification. It is, therefore, through its *quantity* that a current acts on the magnetized needle.

If, now, we take a thermo-electric pair, zinc and copper of five square milimetres, heat one of the solderings to 40 degrees, and complete the circuit by the sort of multiplier which we had previously formed, the needle will be not at all deflected; the electricity will not pass. But if we retrench 1,800 coils and shorten the conductor to this extent, the multiplier, now reduced to 200 coils, will begin to give notable deviations. If we reduce it to 10 coils, the deviation will be considerably augmented. If, in fine, we reduce it to a single coil, formed of a strip of copper containing as much substance as the 2,000 coils, the deviation may proceed even to 60 degrees.

The quantity of electricity produced in this experiment by the thermo-electric pair is evidently 2,000 times greater than that of the above hydro-electric pair, since we obtain the same deviation with a single coil as with the factitious quantity given by the reduplication of the coils. Nor is this all: in the first experiment the length of the conducting wire was easily traversed by the hydro-electric current; the inertia of the matter was overcome without difficulty and without appreciable loss of the current. In the second experiment this inertia could not be overcome; the power of action was insufficient, and it was necessary to reduce the circuit to a very small length for the electricity to be able to traverse it. There are two quite distinct conditions, then, which we must not confound: to act by the *quantity*, or to overcome the resistance of the conductors by a power independent of the quantity, and which Peltier called *intensity*, reserving the name of tension for static electricity.

To throw better light on the nature of these phenomena, Peltier varied the experiments. He formed a quintuple helix of 240 coils; in other words, on a helix of 240 coils he superposed a second in all respects similar, but insulated from the first, then a third, a fourth, and finally a fifth. This quintuple helix was so constructed that the homologous ends might be united and then form but one helix of 240 coils, having five times more of substance; they might also be united in a battery, that is to say the end of the first might be joined to the beginning of the second, the end of the second to the beginning of the third, &c.; forming thus a helix of 1,200 coils, being a helix five times longer, but having five times less substance than each spire.

When a magnetized bar is placed in this apparatus to produce a current of induction, results exactly inverse are obtained according as one or the other of these last arrangements is employed. Suppose that we unite the helices by their homologous ends, and that we have taken a rheometer of a single coil, the deviation will increase as the number of helices united by their homologous ends; that is to say, as the quantity of substance modified. Thus, assuming that with one helix we have 5° of deviation, with two we shall have 10°, with three 15°, and proportionally with five 25°. If we replace the galvanometer of one coil by a multiplier of 2,000 coils, we shall have 35° of deviation with a single helix. But we obtain no more by employing two, three, four, or five helices, still supposed to be united by their homologous ends.

Suppose now that in place of uniting the five helices by their homologous ends, we unite them in a battery, and that we make use of the rheometer of one coil; we shall have 5° of deviation with a single helix, and we shall obtain no more with two, three, four, or five helices united in battery. On the other hand, suppose that we employ the rheometer of 2,000 coils, the deviation of the needle will go on increasing in proportion as we augment the number of helices, and it will attain its maximum or 90° after the fourth.

Thus we see there is complete opposition between the results, the reason of which is simple: with a rheometer of a single coil, the resistance of the conductor may be considered as null. When the helices are united by their homologous ends, the quantity of substance altered is augmented, and consequently the quantity of electricity produced. Now, as the conductor offers no resistance, this constantly increasing quantity of electricity passes without difficulty and gradually augments the angular deviation of the needle. On the contrary, when we take a rheometer of 2,000 coils, the resistance of the conductor is great, the quantity of electricity produced is in vain augmented; no more of it passes, it returns backward and is neutralized by the electromoter itself. The sole means of making more pass, is to unite the helices in battery; then, in effect, we augment the difficulties to the retrogradation of the two electricities, and force them consequently to recombine in advancing. Peltier formed still another multiple helix, of which the wires were of different and proportioned magnitudes. The result was still that the quantity was given by the mass, and the intensity by the reduplication of the spires. He repeated the same experiments with thermo-electric and with hydro-electric pairs. These gave analogous results; the quantity depended on the quantity of matter altered in each element, and the intensity on the number of interposed pairs undergoing the same alterations. We shall content ourselves with speaking of the results yielded by the hydro-electric pairs.

In one experiment, five square centimetres of a voltaic pair, immersed in acidulated water, gave two proportional degrees:

10 square centimetres gave	40°
15 square centimetres gave	60°
20 square centimetres gave	80°

In this experiment the conductor was short and very large, consequently the resistance might be considered as null; on repeating the same experiments with

a battery of six pairs of the same dimensions, the same results were obtained, and not a degree more.

If, on the contrary, the interposed arc conducts feebly, the angular deviation is no longer proportional to the surface immersed In another series of experiments, Peltier caused a current to pass into a trough full of water, in which he could interpose, at pleasure, diaphragms of platina, and he reached the following results:

Number of pairs in action.	0 diaphragm.		1 diaphragm.		2 diaphragms.		3 diaphragms.	
	Degrees.	*Forces.*	*Degrees.*	*Forces.*	*Degrees.*	*Forces.*	*Degrees.*	*Forces.*
1	5	5	3	3	2	2	1	1
2	40	102	21	21.2	14	14	12	12
3	60	391	32	48.5	24	25	20	20
4	65	519	42	123	32	48.5	26	28
5	.....	.....	50	228	40	105	31	44
6	.....	.....	55	302	45	160	35	64

The galvanometer employed in this experiment was an instrument of 430 coils.

The inspection of this table suffices to remove all doubts: as long as there was no diaphragm, two pairs were sufficient to give 40 degrees of galvanometric deviation, equivalent to 102 of force; when there were two diaphragms, five pairs were needed to arrive at the same angular deviation. When there was one diaphragm, three pairs gave $32^\circ=48.5$ of forces; with two diaphragms there was but $24^\circ=25$; to regain the 32° it was necessary to employ four pairs. With three diaphragms there resulted for three pairs only $20^\circ=20$; for four pairs only $26^\circ=28$. To regain or nearly regain the $32^\circ=48.5$, it was necessary to employ five pairs. In effect, by taking three pairs, there resulted, with one diaphragm, $32^\circ=48.5$, with two diaphragms $24^\circ=25$, with three diaphragms $20^\circ=20$. Thus the quantity of the current continued diminishing in proportion as the resistance of the conductor augmented. Further, to regain that quantity, it sufficed to increase the number of pairs; then, indeed, the resistance of the conductor was overcome and the same quantity of electricity passed anew.

The inspection of this table proves, therefore, that to have the same number of degrees after a different number of alternatives, it is necessary to modify the electric source, and that the same deviation can never be reproduced after the addition of a diaphragm, if the number of pairs be not augmented. The table shows, also, that the loss of the current is so much less as the current has already traversed a greater number of diaphragms. Thus, we find in the second line for two pairs 102, 21.2, 14, and 12. The first diaphragm, therefore, has caused the current to lose $\frac{4}{5}$ of its quantity; the second, $\frac{2}{3}$; the third, $\frac{1}{7}$. It is not, as has been said, that the electricity, better sifted, passes more easily through the new obstacles opposed to it; the electricity has not changed its nature, but it is that after having traversed, say two diaphragms, if a third be presented to it, it has, in order to retrograde, to surmount anew the resistance of the first two diaphragms; it is no longer simply the obstacle of the battery which opposes itself to its equilibration in returning, there are besides the two diaphragms which it has already passed. From this it results that the more diaphragms the current has traversed, the more resistance it finds in its return, and the less loss it sustains consequently by the interposition of another diaphragm.

From what precedes we shall readily comprehend the gravity of the error committed by physicists, and especially by the German physicists, who, in their experiments on currents, in general only consider the current itself, and take little or no account of the electro-motor. A current, however, is not an ideal existence which can be divorced from the source which gives rise to it.

Ohm and Gauss have, in their formulas, recognized as a principle that metallic threads oppose to the passage of electric currents a resistance always directly

proportional to their length, and inversely proportional to the surface of their transverse section. It would be desirable, certainly, that this law might be considered exact; but unfortunately it is not so, for Peltier has demonstrated that there are very great differences between the losses undergone by a current which traverses different lengths of the same wire according to the kind of electro-motor employed; according as we have to do with a hydro-electric pile, a thermo-electric pile, or with electricity by induction. Further, for the same electro-motor the results vary according to the greater or less power of the disturbing action.*

Reply of Peltier to an objection made to the chemical theory of the voltaic pile.—The partisans of the theory of contact had often objected that it is not always the bodies most strongly attacked which give most electricity. How, said they, should chemical action be the cause of currents, when we obtain by the least oxidation of zinc in pure water a current superior to that given by copper plunged in nitric acid, which devours it in a few instants? Peltier has supplied the explanation of this apparent anomaly.†

To have full *(nombreux)* currents, it is not only necessary that there should be much electricity produced, but, moreover, that the two electricities should be collected, each separately, at the moment of their production; this takes place with the zinc, but does not take place with the copper. When an acid attacks and oxidizes the zinc, that oxide remains adherent to the metallic plate; the negative electricity can therefore easily diffuse itself over this last. On the contrary, when the acid attacks copper, the resulting oxide does not remain adherent to the metal; it falls into the acidulated liquid, leaving the copper still bright and clean. Of course, in this case, there must be a vast quantity of electricity lost; in effect, the chemical combination is no longer accomplished, as in the preceding case, in contact with a good conductor; it takes place in the midst of an acidulated liquid; it hence results that the negative electricity is recombined, in part at least, with the positive electricity which is present in the acid.

What has been said above explains the utility of the amalgamation of the positive elements in batteries; the combination of the oxygen of the solution not being capable of accomplishment except in the interstices of the mercury, the electric phenomenon is enveloped by a conducting metal, and the resinous electricity, thus collected from all parts, is propagated through the conductor to become again neutralized with the vitreous electricity abandoned to the liquid.

IV.—Cyano-polarimetry.

Peltier had occupied himself much with that branch of the physical sciences which treats of light. It will be readily understood that, desiring to penetrate as far as possible into a knowledge of the intimate structure of bodies, he would not neglect the study of optics. There is, indeed, no science more useful or necessary in this point of view, for there is none in which molecular actions and influences are more distinctly defined; there is none of which the general theory is so complete and satisfying. Independently of many other circumstances, this is referable to a fact which has not perhaps been sufficiently remarked. For the study of caloric, of electricity, of magnetism, there is always need of instruments, and these instruments, products of our industry and ingenuity, are always more or less awkward; we must have recourse to the thermometer, the galvanometer, the different compasses of declination, inclination, &c. For light, on the contrary, we need them not; the instrument has been conferred on us ready made by nature, and is of an admirable sensibility: it is the eye. Peltier had given, therefore, much attention to the phenomena of light and had perfectly

* Peltier: Communication to the Academy of Sciences on electric conductibility. *Comptes rendus*, t. 1, pp. 203, 1835.

† See *Comptes rendus* of the Academy of Sciences of Paris, 1837, t. 4, p. 65, and the *Dictionnaire Univers. d'Histoire Naturelle*, article Galvanism.

mastered them; but he had experimented little, and all that remains to us of his in this branch of physics is the improvement which he applied to the cyano-polarimeter of Arago.

Every one knows how much the azure color of the sky varies with the quantity and state of the vapors diffused in the atmosphere; every one knows also, since the discovery of M. Arago and the researches of MM. Quetelet and Delezeune, that the air polarizes light and that the intensity of this polarization is not the same at all points of the sky, nor the same for the same point at all hours. There was nothing, for a long time, wherewith to measure the variations of the azure of the sky but the cyanometer of Saussure; for the cyanometer of Arago, as designed by him in 1817, had never been realized. As to the polarization of the atmosphere, there existed for its study only the polariscope of Savart and that of Arago. But the cyanometer of Saussure is a very imperfect instrument which can yield none but very uncertain results; as regards the polariscopes of Savart and Arago, they are both, it is true, extremely sensitive, but as they are destitute of the means of measurement, they could not serve for exact observations.

In the sitting of 25th of October, 1841, Arago communicated to the Academy of Sciences a polarimeter of his own invention. This instrument was the polariscope proposed by the same savant in 1811, but to which a particular apparatus had been adapted. The polariscope of Arago becomes a polarimeter by the sole addition of one or more plates of glass with parallel faces, placed in front of the old instrument. These plates are movable. A graduated circle indicates the inclination under which the light has traversed them, before penetrating into the polariscope, properly so called. The proportion of polarized light contained in the pencil observed is deduced from the angle at which it is necessary to adjust the plates of glass in order to perceive no longer any trace of color athwart the whole apparatus.

In the sitting just mentioned, Arago had presented to the academy the instrument as constructed and arranged by himself; at a succeeding session, November 15, he submitted to the inspection of the academy this same polarimeter constructed upon his model, but executed by M. Soleil; this instrument is known as the cyano-polarimeter of Arago. Capable of serving at once as a cyanometer and polarimeter, it was, beyond doubt, greatly superior to the instruments previously in use for studying the variations of the blue color of the sky and the differences in the quantity of light polarized by the atmosphere; yet was it not without defects: first, as concerns cyanometry, it wanted several important means of measurement; then, as regards polarimetry, it could in reality render service in only two rectangular planes: in the plane, namely, of the meridian, and in that of the equator of the aerial sphere, of which the sun is one of the poles, and the anti-sun the other pole; outside of these two planes, it could be of no utility. Peltier applied himself to correct these defects, and completely succeeded in doing so.

Optical principles of cyanometry.—If we take a crystal having a single axis of double refraction, such as Iceland-spar, the beryl, &c., and cut from its mass a slip of which the two faces shall be exactly perpendicular to that axis, and if we then cause a ray of polarized white light to fall perpendicularly on this slip, so that it shall traverse the crystal exactly in the direction of its axis, the ray will undergo modification. If we now analyze it on its emergence with an achromatic double-refracting prism, taking care to place the principal section of this prism in the plane itself of the polarization of the ray, the ordinary image contains the entire ray; that is to say, the complimentary tints are black and white, and there is no coloration. Quartz, however, forms an exception to this rule. When, in effect, a ray of polarized white light is made to pass through a lamina of quartz (rock crystal) cut perpendicularly to the axis, and this ray, as in the previous case, exactly follows the direction of the axis, if we in like man-

ner analyze it at its emergence with an achromatic double-refracting prism, we shall see two images always colored and presenting complementary colors which change when the bi-refracting prism is made to revolve. The reason of this difference is the following:

A ray of white light polarized is a ray of which all the constituent colored rays have vibrations which are always executed in the same plane. Now, if such a ray be made to pass through a crystal with a single axis, the planes of polarization of these different rays are not modified. The colored rays issue from it as they had entered, and consequently the bi-refracting prism employed to study the white ray at its emergence can produce no other phenomena than those which it produces with all ordinary polarized rays.

It is not the same when quartz is employed. This mineral, in effect, has the property of deflecting the plane of polarization of the different-colored rays constituting the polarized white ray. The lamina of quartz turns these different planes around its axis, so that the planes might be said to follow a spiral situated within the crystal; the plane of polarization of the red ray is the least deflected, being that which makes the smallest angle with the primitive plane of polarization; on the contrary, the plane of polarization of the violet ray is most deflected, being that which makes the greatest angle with the above definitive plane. It is thus seen that in the deflection of their planes of polarization, the rays follow the order of their respective refrangibilities, beginning with the least refrangible. When, therefore, the polarized white ray issues from the lamina of quartz, the colored rays which constitute it have each their plane of special polarization—have each particular and different planes in which their vibrations are performed. When we proceed, then, to analyze such a ray with an achromatic double-refracting prism, the colors are distributed in unequal proportions among the ordinary and extraordinary pencils, which consequently produce colored and complimentary images.

The planes of polarization of the colored rays which have traversed the axis of a lamina of quartz deviate from their primitive position by a quantity proportional to the thickness of the lamina. They exhibit a double angular deviation for a double thickness, and, at the moment of their emergence they present precisely the position in which they would occur if they had been made to turn uniformly in the same direction around the axis during their transit through the lamina. From this it will be seen, that by giving to the lamina of quartz a sufficient thickness, the primitive plane of polarization of a ray might be made to turn even several semi-circumferences. This shows that there is a fundamental difference between the action of the quartz on a polarized white ray, and that of a prism of glass on a ray of natural light; it is, in effect, that the first is a molecular action, while the second is due only to the difference of refractive power of the surfaces.

By giving a suitable thickness to the lamina of quartz, we may obtain, therefore, such a tint as is desired for a given position of the principal section of the prism. M. Arago has, with reason, chosen the thickness which gives a pure blue of the second order in the ordinary image; this thickness is in general from six to seven millimetres.

It results from what has been said, that the intensity of the blue color in the ordinary ray depends upon the perfection of the polarization of the ray which falls on the lamina of quartz, on the thickness of that lamina, and on the position of the bi-refracting prism. For a constant thickness of the lamina and an equally constant position of the bi-refracting prism, the intensity of the color can, therefore, only depend on the greater or less perfection in the polarization of the incident ray; in other words, on the relative polarization of that ray. Now, when the pile of glasses in the cyano-polarimeter is perpendicular to the incident ray, the polarization is null, and consequently the coloration is equally null. The more the pile is inclined and the incidence of the ray oblique, the

more perfect is the polarization and the more intense the blue color of the ordinary ray. For a pile of eight glasses, the polarization may be considered as perfect when the ray of light reaches it under an incidence of 10 degrees; it is at that point, therefore, that we should have the most intense blue, and it is evidently this angle which might serve as a point of departure, were it not for the circumstance which I am about to mention. The pile of glasses transmits, in effect, only a part more or less considerable of the incident light, and reflects the rest. Now, when the incidence of the ray is too oblique, the quantity of reflected light is so much augmented that more is lost in vivacity of color by the reflection, than is gained by the perfection of the polarization. There is, therefore, an angle at which the polarized ray gives a maximum of the image; that point passed, the ray still gains in polarization, but loses considerably in brightness. It is thought by most authors that this maximum is obtained when the pile of glasses makes with a perpendicular to the ray an angle of 55°; in other words, when the ray reaches the pile under an incidence of 35°.* It is in fact under this angle that we obtain the maximum of absolute, but not of relative polarization.

This is the angle also that Peltier has taken as being that which gives the maximum blue. I confess, however, that it has appeared to me that we should still gain by continuing to incline the pile. We lose, it is true, a little in light, but to me it has seemed that the blue tint became more pronounced. I think that the angle which gives the maximum of coloration is rather between 25° and 30° than at 35°; it may be, however, that this would vary according to the individual.

Optical principles of polarimetry.—We now pass to polarimetry. In researches on this subject, the observer is always supposed at the centre of a sphere of which the sun is one of the poles and the anti-sun the other. This sphere has its meridian and its equator, endowed with the properties which characterize those great circles.

We will suppose, then, the axis of the objective tube to be in the plane of the meridian, the pile also, and moreover rectangular with the incident ray; we will suppose, in fine, that the index of the ocular points to the zero of the graduated circle. If now, by means of the vertical joint, the objective tube be carried successively to all points of the meridian of the optical sphere which we are considering, the following is what we observe: the rays proceeding directly from the sun and those little distant from them give no signs of polarization, and consequently no coloration in the images, but in proportion as the angle of the radius vector with the direct rays of the sun is enlarged, the signs of polarization supervene and coloration makes its appearance. The extraordinary image takes the blue color, and the ordinary image assumes the orange-yellow complementary tint.

The intensity of the tints increases up to about 90°, that is to say, to about the point of intersection of the meridian and equator; thence it decreases till about 150°. This number attained, we find the neutral point for whose discovery we are indebted to M. Arago. Beyond this, polarization is again reproduced, but in an opposite direction; that is, the plane of polarization of these new polarized rays is perpendicular to the plane of polarization of the preceding; consequently it is no longer the extraordinary image which is colored blue; it is the ordinary image.

This singular change in the plane of polarization of the reflected rays results from the circumstance that that portion of the sky no longer reflects the rays proceeding directly from the sun in so great quantity as the rays proceeding from the different illuminated points at the horizon. Consequently the neutral of M. Arago evidently results from the union of equal rays polarized rectangu-

* Peclet, *Traité de Physique*, § 1439, p. 447.

larly, for such rays conduct themselves like the rays of natural light. M. Arago has remarked, moreover, that this point does not always correspond to the vertical plane passing by the sun, but that it is sometimes found diverted to the right or to the left, when the reflection is altered in one of the reflecting sectors, whether this alteration proceeds from the presence of clouds, or from that of diffused vapors, or from the neighborhood of a mountain, &c.

We will not enter into further details on this subject; it may suffice to direct the reader's attention to the original researches of M. Arago, as well as to those of MM. Quetelet and Delezenne.* It may be stated, however, that a second neutral point has been found by M. Babinet, about 30° above the setting sun, and a third by Mr. Brewster, below the setting sun; but these two neutral points are rather difficult to be observed. All these neutral points, it may be added, exist only in the meridian or in the great circles but slightly remote from it.

We have supposed that the pile was placed in the plane of the meridian, and that it presented itself perpendicularly to the incident ray. If during the movement communicated to the eye-glass along the meridian, we incline the pile on the axis of the luminous pencil, the intensity of the colors will be seen to diminish; in a word, the pile then depolarizes the atmospheric ray. It depolarizes it, however, unequally, according to the direction that is given to its inclination; for if it is inclined towards the sun it depolarizes rapidly and completely, while if it is inclined in the other direction, towards the opposite pole, it depolarizes much less and often very little.

If now the tube of the eye-glass be turned in its collar, so that the plane of the pile shall be perpendicular to the meridian, and if, in this new position the pile be inclined on the incident ray, the intensity of the tints is augmented, instead of diminishing as in the previous case. Thus, in the first position, that of the pile in the plane of the optical meridian, the pile in inclining depolarized the rays of the atmosphere; in the second, on the contrary, it adds new polarized rays to those which already existed.

Instead of placing the instrument in the plane of the meridian, the observer may place it in the plane of the equator; suppose, then, the objective tube of the polarimeter in this latter plane, and that the pile also be in the same plane, and thus presents itself perpendicularly to the incident rays; if now we direct the instrument in succession to all points of the equator, from the maximum point, which has its place on the meridian at the intersection of these two great circles, to the horizon, we shall find the extraordinary image colored blue; moreover that it preserves the same intensity in the whole line of the equatorial circle; only in approaching the horizon, the tint becomes a little weakened, through the vapors diffused in the strata of air very near the surface of the globe. We have supposed the pile in the plane of the equator and perpendicular to the incident rays; if we incline it on those rays the intensity of the colors is augmented; if, on the contrary, we place it perpendicularly to that plane its inclination depolarizes the atmospheric rays and renders the images colorless.

Thus in the two great rectangular circles which we have been considering, one forming the meridian of the optical sphere and the other its equator, the extraordinary ray is blue, the ordinary ray has the complementary tint, orange yellow; the pile adds to the atmospheric polarity when it is parallel to the equator, while, on the contrary, it depolarizes when perpendicular to it. As to the horizon, if we examine it at the moment of the rising or setting of the sun, it will be found that the coloration is null for the rays which proceed directly from that luminary; that it increases up to about 90°; that it then diminishes till about 180°, where it is at its minimum; that it recovers anew till about 270°, where is found a second maximum, to again disappear when it falls within the too direct rays of the sun.

* See the *Correspondance Mathématique* de M. Quetelet, t. 1, pp. 275 and 338.

From the above, it is seen that the maximum of coloration is always found in the extraordinary image, with the sun at 90°. Now, it is evident that this should be so, since the angle of maximum polarization for the air is precisely at 45°.

If we look with the objective tube of the polarimeter towards a point of the heavens situated outside of the optical meridian and equator, the blue of the extraordinary image is altered; it becomes violet, or else green, according to the direction of the displacement. This change in the tint of the images indicates an equivalent change in the plane of the reflector or polarizer. To regain the blue, it is necessary to turn the bi-refracting prism by an angular quantity equal to the supposed angular deviation of the reflector, with a view to replacing the principal section of the prism in the same relation that it had with the plane of the polarized ray before this deviation of the reflector; we therefore turn the ocular tube which bears the bi-refracting prism, until we shall have recovered the blue; then we carefully note the number of degrees by which it has been turned, for it is this notation which gives the position of the plane of polarization in the point of the atmosphere which we may be studying. Unluckily, the rotation which has been communicated to the ocular to restore the blue of the extraordinary image, has at the same time destroyed the blue of the ordinary image which proceeds from the pile and from the other lamina of quartz—that is to say, the blue which is to serve as a point of comparison; it was requisite, therefore, to find the means of reproducing the normal blue of the ordinary image.

To attain this result, Peltier covered the cap of the left and his lamina of quartz with another cap, turning with easy friction. In this new cap he set a lamina of mica of a thickness sufficient to restore to the image its normal blue by turning the cap on itself, and placing by this means the principal section of the lamina of mica in the plane necessary to obtain this restoration of the blue.

V.—Meteorology.

Introduction.—Astronomical and meteorological phenomena are, beyond question, the first which must have attracted the attention of man. The diurnal movement of the sun, its annual movement and the periodical return of the seasons, must have so much the more interested him as they bore directly on his existence and his material well-being. On the other hand, the astounding spectacle of storms, the lightning and the thunder, could as little fail strongly to impress his imagination. Everything, therefore, would lead us to conclude that, from the earliest times, mankind have been seriously occupied with the study of the different phenomena of astronomy and meteorology.

But if these two sciences were born at the same time, they are far from having made the same progress. Astronomy has long ago attained a certainty so great that it may be considered in this respect the first of all the sciences of observation; meteorology, on the contrary, is still in its infancy. The reason of this difference is easily comprehended. The movements of the heavenly bodies are subjected to a small number of very simple laws, always identical; meteorological phenomena, on the contrary, are generated by the action of a host of different causes, all widely diverse, and highly variable as to their nature, their mode of action, their power and their mutual influence. But this is not all: to arrive at the point it has attained, astronomy has had to ask little succor from the other sciences; it has, in some sort, had need only of direct observation for the registration of facts, and of mathematics for their co-ordination and the deduction of consequences. It is not so with meteorology, for meteorology is most frequently only the application of the different laws of physics to a particular class of phenomena, and could not exist in an independent manner; meteorology, therefore, could make no real progress until other sciences, and especially physics, were sufficiently advanced to constitute a satisfactory body of

doctrines. Now, the most important part of physics for meteorology, electricity, dates back scarcely a century. The discovery of the Leyden jar by Musschenbroeck and Cuneus dates from 1746, the experiments of Dalibard and of Franklin from 1752; what could meteorology be before that epoch? Evidently it could consist only of theories, of suppositions more or less vague and unmeaning; in fact, before that epoch, but little consideration was applied to it. It was quite otherwise after the period in question; the discovery of Musschenbroeck had aroused all thinking minds; the analogy between the electric spark and the thunderbolt appeared evident; all the world threw itself with ardor into the study of electrical phenomena on the one hand, and of meteorological phenomena on the other; a great number of savants devoted themselves to the study of atmospheric electricity, and if the results at which they arrived had not at first all the precision that might be desired, they always maintained an interest which fostered and kept alive the general attention.

The number of savants who occupied themselves with experiments on atmospheric electricity in the second half of the eighteenth century was very considerable. Some of these, like Lemonnier, Ronayne, Read, Schübler, made use, by preference, of fixed apparatus, while others, like Romas, the prince Galitzin, Musschenbroeck, Van Swinden, the duke de Chaulnes, Bertholon, Franklin, Cavallo, joined thereto the use of the electrical kite. Beccaria, who had at first experimented only with fixed apparatus, employed also the electrical kite at a later date.

The results at which these savants arrived were most contradictory. Romas, Galitzin, Musschenbroeck remarked from the beginning that the electric signs varied with the course of the kite; on the other hand, Beccaria, Read, Schübler, complained of the little accordance of the fixed apparatus; hence it was impossible to reach a conclusion even approaching certainty. Yet, as doubt is always painful to the human mind, it came to be admitted generally, on the one part, that the air was electrical; on the other, that the electricity of the air proceeded from the evaporation which takes place at the surface of the soil. For the substantiation of this opinion, reliance was placed on the old experiments of Volta, Lavoisier, and Laplace, and on the more recent ones of M. Pouillet. These experiments consisted in projecting water on a body raised to a high temperature; but it was M. Pouillet alone who had employed a crucible of platina in place of an oxidizable metal as the other physicists had done. In these experiments the vapor formed, almost always yields electricity, and when it does so it is always vitreous electricity.

The first thing which Peltier did was to repeat, while he also simplified, the experiment of Pouillet, and he showed that the formation of vapors only gives an appreciable electricity when the vase has a temperature of at least 110 degrees; that below that temperature the instruments can no longer collect any, and that, in fine, even at that temperature they can only collect it when there has been calefaction and then decrepitation of the drop of water projected.* The high temperature and the assemblage of phenomena necessary to maintain separate the electricities produced, never meet together in our ambient medium; never does the vapor, when it rises on the surface of the soil, possess any considerable tension; hence spontaneous evaporation gives no electrical signs, unless under circumstances wholly peculiar.

Spontaneous evaporation being incapable of communicating electricity to vapors, and those of the atmosphere containing considerable quantities of it, Peltier felt engaged to seek the true origin of that electricity. He recurred, therefore, to an old experiment of Saussure and Ermann, which in their hands had been barren of results; and as this experiment may be considered as the

* See the note of Peltier contained in *l'Institut*, vol. ix, p. 31; and his memoir on *atmospheric electricity*, Ann. de Chim. et de phys., 3 series iv, p. 385.

fundamental basis of all meteorology, we judge proper to recite it here with some details.

A place is selected perfectly uncovered and commanding all the environing objects; an electroscope is to be taken furnished with a stem of about four decimetres, surmounted by a ball of polished metal of a radius of from three to four centimetres, with a view to augment the effects of influence and to avoid the efflux of the electricity which may be repelled into the upper part; the instrument is to be held with one hand, the equilibrium to be managed with the other, in putting in communication the stem and the foot. All the reactions being equal on one part and the other, the gold leaves of the electroscope fall straight and mark zero. In this state of equilibrium the instrument may be left in contact with the free air for a whole day under a clear sky without the least sign of electricity being manifested; it may even be moved and the air agitated; as long as the instrument is kept at the same altitude it remains completely insensible. But if, instead of leaving it in the same horizontal stratum of air, it be elevated from four to five decimeters, the gold leaves are at once seen to diverge and to indicate a vitreous tension. If the instrument be replaced at the point of departure the leaves again fall exactly to zero; if it be sunk lower than this point of equilibrium the leaves diverge anew, but now they are charged with resinous electricity. On raising it again to the point of departure the instrument resumes its zero, and retains nothing of the free electricities which it has for an instant shown.

Since no free electricity has remained in the instrument the air has of course communicated nothing to it, and the electrical signs which the instrument had presented proceeded only from the electricity developed in its interior by the influence of a neighboring body in proportion as it was brought nearer to or removed further from it, by elevating the instrument above the point where it had been in equilibrium or depressing it below that point: it suffices, in effect, to replace the instrument at the same point to cause them to disappear. They were, I repeat, nothing more than signs of electricity by influence, such as may be perceived in bodies which are brought near to or removed from another body charged with free electricity, a phenomenon which may be reproduced in the closet by placing one's self on a resinous or a vitreous surface. The consequence of this experiment is that dry air is not electrical of itself; that the earth has a resinous tension, and space a vitreous tension. We may, in effect, interpret this experiment in relation to space, or in relation to the earth. In the first case we say if, after having placed an electroscope in equilibrium at a certain height, we raise it to a greater height, we approximate the terminal ball to the celestial space or to the vitreous body. This latter then acts with more efficacy; it decomposes a portion of the natural electricity of the ball, attracts the resinous and repels the vitreous in the gold leaves which diverge and indicate a vitreous tension. In the second case we say if, after having placed an electroscope in equilibrium at a certain height, we raise it to a greater height, the foot of the instrument, forming with the arm which lifts it the extremity of a point more elevated and conducting, becomes charged thereby with a more considerable resinous tension; the resinous electricity thus accumulated in the platina and in the armatures acts now with more force, decomposes the natural electricity of the upper part of the instrument, repels the resinous in the terminal metallic globe, and attracts the vitreous in the gold leaves which diverge. As may be seen, these two interpretations end in the same result; but, according to the ideas of Peltier on electricity, the last alone is logical and admissible.

Peltier may be considered as the founder of meteorology. No doubt, before him, a great number of distinguished savants had occupied themselves with this branch of knowledge; among the more recent it might suffice to mention MM. de Humboldt, Boussingault, Kaemtz, Quetelet, Lamont, Arago, Gasparin, &c., &c. But all these savants starting with the erroneous principle that the

air is, in itself, electrical, and that it is vitreous, had not been able to draw any general conclusion, to deduce any law from their observations. There had been, unquestionably, meteorological observations at once curious, interesting and exact; there had been, indeed, a great number of them; but as nothing connected, co-ordinated, concatenated them with one another, meteorology as a science did not yet exist; it was Peltier who founded it, for it was he who first stated its laws; of this the reader will be convinced by a perusal of the summary review which we propose to give of the discoveries and ideas of Peltier on this subject, based on his published researches.*

The principal works of Peltier on meteorology are the following: first, his *Traité des trombes*, (on water-spouts,) published in 1840; his memoir on the electricity of the atmosphere, published in 1842 in the *Annales de Chimie et de Physique*, (3d series, vol. iv, p. 385;) his memoir on fogs, which may be found in the 15th volume of the *Mémoires de l'Académie de Bruxelles*, and has been reproduced in the *Annales de Ch. et de Physique*, vol. vi, p. 129; his writings on *electric meteorology*, printed in the *Archives d'Électricité de Genève*, 1844, vol. iv, p. 173; finally, his great memoir on barometric variations, published in volume 18th of the *Mémoires de l'Académie de Bruxelles*. To these should be added certain articles of the *Dictionnaire Universel des Sciences Naturelles* (etoiles filantes, foudre, galvanism, grêle, &c.,) and many other less important communications, composed in the form of letters, whether to the Academy of Sciences of Paris or to the *Société Philòmatique*.

Distribution of diurnal vapors under the double influence of the earth and the tropical current.—The diurnal vapors situated between the earth and the tropical current, that is to say, between two like forces acting in a contrary direction, are divided into three very distinct strata.† The lowest, that which receives most immediately the resinous influence of the globe, becomes vitreous. The portion next to the surface cannot, it is true, long retain its electricity, for the proximity of the earth too greatly facilitates its efflux; it is only the zone placed at some distance which is sufficiently insulated to preserve a part of its own. The inferior vapors, in assuming the globular form, become white and humid; they form the ordinary fogs, which so easily resolve themselves into dew or drizzling rain through the attraction of the globe.

The cause which develops in the inferior vapors a vitreous electricity is also found in the tropical current, charged like the globe with resinous electricity; it repels from above downwards the resinous electricity of the diurnal vapors, as the earth repels it from below upwards. The most elevated portion of these vapors, being thus subjected to a resinous influence, becomes also charged with vitreous electricity. As they grow opaque, these vapors assume a tint of glowing white, and form the beautiful cumulus or brilliant cirrus which appears at a great elevation. The vapors which receive the resinous electricity, repelled from above downwards by the tropical current and from below upwards by the earth, extend in large, slaty bands which can acquire no great thickness, since they are confined by these two antagonistic forces. In a word, the diurnal vapors, such as rise every day in all countries, and which diffuse themselves between the earth and the tropical current, are divided into three well-defined and distinct strata, as, in summer and in the country, may readily be discerned after the setting of the sun. A light, whitish mist is then observed in contact with the earth; above this appear large grayish strata; still higher, white masses of cumulus, or sometimes the refulgent cirrus which seems to stretch away towards the tropical current.

* It has been deemed proper to restrict the translation to a few heads only of this review, and the reader must be left, therefore, in a measure to his own surmise as regards the degree in which filial veneration may have prompted the absolute claim here advanced on behalf of Peltier to be regarded as the founder of meteorological science.—Tr.

† Peltier, *Mémoire de Météorologie Électrique*; *Archives d'Électricité de Genève*, 1844, vol. iv, No. 14.

The succession of electrical signs is accordingly as follows: the earth is resinous; the inferior vapors which give rise to the white mists are vitreous; the middle vapors, which produce by their condensation the large, slate-gray strata, are resinous; the superior vapors, which in their turn generate the voluminous white cumulus, are vitreous; and, finally, the tropical current which overtops the whole is again resinous, like the earth.

In a medium so movable as the air, and subject, moreover, to so many different influences, this triple distribution has stability only for the succession of vapors in time and space, and not for those which, at a given moment, form the triple superposition. We have before said that the inferior vapors retained but for a short time their vitreous electricity, and that they quickly resolved themselves into drizzling rain; but that is not all. When, through the lowering of the temperature, the vapors have ceased to ascend and to thus feed the superior zone, the cumulus which is suspended therein disappears by degrees under the form of elastic vapors. This new transformation is effected so much the more rapidly as the air at that altitude is drier, and as the electric action of the tropical current is more intense.

The inferior vitreous vapors, those which presented themselves under the form of mist or fog, being resolved into drizzle or dew, the visible, superior, vitreous vapors, those which presented themselves under the form of cumulus, having returned to the state of elastic vapors, there remains in the atmosphere nothing but the intermediate vapors, which are alone seen at evening and at night, extended in long, opaque curtains, forming clouds of a slaty gray. Surrounded by an electricity of the same nature as the globe and the tropical current, the repulsion which these clouds encounter on each side retards their re-vaporization; they repass into the state of elastic vapors only when, notwithstanding the re-vaporization of the white and vitreous clouds, the air is still far from saturation; they change their state by the sole force of hygrometric affinity, and not by the help of electric attractions, as takes place in regard to the two other zones. Hence it often happens that we still see, the next morning, portions of these grayish strata not re-vaporized, and which present themselves under the form of dark spots, or even extensive black bands, strongly relieved by their deep color in the midst of the ruddy hues of the dawn.

On the influence of hydro-meteors on the distribution of temperature at the surface of the ground.—The temperature of a place depends not alone on its latitude; it depends also on its longitude. Thus Eastport, in America, and Stockholm, in Sweden, have a mean temparature of about 5°.5, and yet their latitude differs by 14 degrees. New York and Naples are in the same latitude, but the mean temperature of winter at Naples is 9°.9, while that of New York is—1°.20, the difference being 11.1 degrees.

By uniting by lines all the points for which the mean temperature is the same, we obtain curves which Humboldt first traced on maps, and which are designated under the name of isothermal curves. These lines are very far from forming parallels with the equator: thus the isothermal line of 10° passes successively by Fort George, (10°.1); by Erasmus Hall, near New York, (10°.7); by Dublin, (9°.56); by London, (10.4); by Harlem, (10°.0); and by Odessa, (9°.86); that is to say, by 46°.18 of north latitude; 40°.37; 53°.21; 51°.31; 52°.23; and 46°.28. The extent of the divergence is therefore about 13°. From this we see that the angle under which the rays of the sun strike the earth is not the only element which determines the temperature of a place. Several other causes, in effect, contribute their action.

The trade winds impelling towards the equator masses of air proceeding from high latitudes, refresh the intertropical regions. On the contrary, the warm wind of the southwest, which proceeds from the equator and which sinks towards the earth in proportion as it advances nearer the poles, communicates to the regions which it touches a portion of its heat and moderates the rigor of

their climate. Hence, for the equator, calculation gives stronger temperatures than those realized by direct observation. In higher latitudes, on the contrary, the values to which it leads us are too small. These two results are satisfactorily explained by the opposite influence of the trade winds, which warm the poles and cool the equator. The currents of the ocean join their action to that of the currents of the atmosphere, and concur in warming the countries of the north. Such is, beyond all, the case with the Gulf Stream, which, after bathing the coasts of the United States, presses on in summer as far as Iceland and even the shores of Norway.

The causes which have been signalized are evidently of a nature to modify the temperature of the places on which they act, but they could not have sufficient power to explain the great differences which are sometimes observed between localities, although in near proximity. They cannot especially explain the constant decrement of temperature in the different localities of Europe and of central Asia, in proportion as we advance into the interior of the land.

If we depart from the western coast of Europe and proceed directly towards the east, always advancing under the same latitude, we shall observe the following meteorological phenomena: 1. In proportion as we advance towards the east, the mean temperatures of the year continue to become progressively lower at the places by which we pass. This fact is still more remarkable if, instead of taking the mean temperatures of the year, we simply take the mean temperatures of the winters. 2. It will be found, moreover, that the mean quantity of rain that falls in a year goes on diminishing in proportion as we advance from the west towards the east. 3. Finally, it will be observed that the relative quantity of water which falls in winter continues also to diminish; in other words, if we represent by 1.00 the annual quantity of water, it will be found that in proceeding towards the east the quantity of water which falls in winter becomes a fraction less and less considerable of the whole quantity.

These three facts, namely, the diminution of the temperature, the diminution of the annual quantity of water, and the diminution of the fraction of water which falls in winter, are easily observed in proportion as we advance into the interior of the continent, proceeding from west to east. We will cite several examples:

Mean temperature of winter for one and the same parallel at different longitudes.

Names of localities.	Latitude.	Longitude east of Paris.	Mean temperature of winter in Centigrade degrees.
	° ′	° ′	° ′
Edinburgh	55 58	5 30	+ 3 47
Copenhagen	55 41	10 15	— 0 42
Tilsit	55 04	19 33	— 3 06
Moscow	55 47	35 13	—10 05
Kazan	55 48	47 10	—12 29
Isle of Man	54 12	6 50 W.	+ 5 58
Cuxhaven	53 53	6 24 E.	+ 0 03
Stralsund	54 19	10 45	— 0 17
Dantzig	54 21	16 18	— 1 91
Konigsberg	54 42	18 09	— 3 26
Wilna	54 41	22 58	— 4 60

We will cite further as extreme points the islands of Feroe and Iakoutsk:

Names of localities.	Latitude.	Longitude east of Paris.	Mean temperature of winter in Centigrade degrees.
	° ′	° ′	° ′
Thorshaven	62 2	8 30 W.	+4 3
Iakoutsk	62 1	127 24 E.	−38 9

It has been our purpose, as far as possible, to introduce into these tables only places of little elevation above the level of the sea; so that, in effect, there were no corrections to make in regard to the height. Yet there are exceptions, Moscow being 148 metres above the level of the sea, Kazan 58, Wilna and Iakoutsk 117. These heights, however, are much too insignificant to have any notable influence on the results, for it is usual only to admit a diminution of 1° Centigrade for 200 metres of elevation.

The preceding tables suffice to show the rapid decrease of the mean temperature of winter for the same latitudes in advancing from west to east. The diminution of the absolute quantity of rain in the year and the diminution of the absolute and relative quantity of rain in winter are not less evident. If we count the number of days of rain for the different countries of Europe, we have the following table:

Number of days of rain in different regions of Europe.

Names of regions.	Number of days of rain in the year.	Number of days of rain in winter.	Ratio of this last quantity to the former in hundredths.
England	152	40.3	26.5
Western France	152	37	24.3
Interior of France	147	35.6	24.2
Plains of Germany	141	32.6	23.1
Western Russia	138	29	21
Kazan	90	16	17.5
Iakoutsk	60	6	10

If, instead of taking the number of days of rain, we take the quantity of rain expressed in millimetres, we arrive at the same result:

Quantity of rain in the different regions of Europe.

Names of countries.	Annual quantity of rain.	Quantity of rain during winter.	Ratio of this last quantity to the former in hundredths.
	mm.	*mm.*	
Western England	950	251	26.4
Western France	680	159	23.4
Eastern France	650	127	19.5
Plains of Germany	540	98	18.2
Western Russia	480	82	17
Kazan	350	52	15
Iakoutsk	250	25	10

For further details on this subject recourse may be had to the great treatise on meteorology of Kaëmtz, in 3 volumes, pp. 450, 500; the smaller treatise on meteorology by the same author, translated, with notes by Ch. Martins, p. 138 and seq.; the memoirs of Gasparin on the distribution of rains in Europe, (*Bibliothèque Universelle,* t. 38, pp. 54 and 264;) and the *Atlas Physique* of Berghaus, charts 10 and 12 of the meteorology, p. 19 and seq. of the text.

The tables above given establish, therefore, the three facts in question: the diminution of temperature, the diminution of the annual quantity of water, and the diminution of the relative quantity of water falling in winter. What, now, is the cause of these three phenomena? what is the bond which connects them? It is this which we propose to explain while expressing ourselves with all the reserve which is proper on such a subject.

The winds of the southwest bear from the Atlantic ocean a large quantity of clouds and vapors; these, nearly throughout Europe, are the winds pre-eminently rainy. The clouds are formed of globules of transparent vapor and of globules of opaque vapor, both kept apart by the latent caloric and the electricity, which render them mutually repellant. If any cause abstracts from a cloud the greater part of its electricity, one of the two forces which co-operated to keep the globules separate is suppressed. The globules of transparent vapor approach one another, are condensed, and transformed into opaque vapors; the globules of opaque vapor, for the same reason, pass into a liquid state, the density of the cloud, its specific gravity, is augmented, the cloud sinks and falls on the earth in the form of rain. On arriving at the surface the cloud disengages the latent heat it possessed, and thus the soil, as well as the ambient air, is rendered warm.

The quantity of rain which falls annually is naturally, all else being equal, more abundant in western Europe than in the interior of that continent; the forests, the mountains, especially when wooded, radiate much electricity; they neutralize, therefore, the electricity of the clouds, and thus induce, in a manner more or less indirect, their precipitation. When this current from the southwest reaches Germany it is already deprived of a great part of its vapors. When it arrives in Russia, there remains still less of them; finally, in Siberia there is scarcely any at all remaining. It thus appears that the quantity of water which falls in a year must continue always diminishing as we penetrate into the interior of the continent; it is evident, consequently, that the quantity of latent heat abandoned by the clouds must also progressively diminish, and that the temperature must undergo a corresponding abatement. These facts are more marked in winter than at any other season, because then the wind from the southwest brings a less quantity of vapors, while these are less elevated and consequently terminate at lower latitudes. Another cause, moreover, concurs in augmenting the asperity of the cold in the interior of Russia: this is the intensity of the radiation which takes place in consequence of the great serenity of a sky which is obscured by neither cloud nor vapor.

It results from what has been just said, that a locality in Europe situated to the east of a chain of mountains should always be colder, all else being equal, than a locality situated to the west. The chain of mountains in effect, by precipitating a great quantity of vapors, must have abstracted a considerable portion of the latent heat, which is hence naturally in deficiency on the other side; moreover, if these places are situated in a latitude somewhat high, where the clouds are already very low, this effect will be still more decided. This in reality is what occurs as respects Sweden and Norway in reference to the Scandinavian Alps. We may cite as an example Drontheim in Norway, and Uméo on the Gulf of Bothnia, in Sweden, (see *l'Institut* of 18th February, 1846, p. 61, the communication of M. Martins.) These two cities are nearly in the same latitude, and yet the mean temperature of Drontheim during winter is $-4°.75$, while that of Uméo is—$10°.2$, a difference of $5°.45$.

The same fact is observed, if we compare together Bergen and Stockholm. Bergen is in 60° 23′ north latitude, and west of the Scandinavian Alps; Stockholm is in 59° 20′, and east of that chain of mountains. Bergen is therefore one degree further north than Stockholm, and yet the mean temperature of winter at Bergen is +0°.79, while at Stockholm it is −3°.61, a difference of 4°.4. Besides this, the quantity of water which falls in a year at Bergen is enormous; it reaches 2,250 millimetres, and in winter 598. At Stockholm, on the other hand, the quantity of water which falls in the year is but about 520 millimetres, and the fall in winter 76. In the latter place, then, there falls in winter about eight times less of water than at Bergen. Moreover, if the total quantity of rain falling in a year be represented by 100, it will be seen that at Bergen there falls in winter 26.6, while at Stockholm there falls but 14.8. These two places, therefore, fully confirm the facts which we have above indicated, and lend their support to the explanation which we have given.

Hydrometeors influence also the mean temperature of summer; in general, when we penetrate into the interior of Europe, pursuing always the same line of latitude, the mean temperature of summer will be found progressively growing higher; the difference, however, being not so great as for the winter, and in the inverse direction. This is generally attributed to the fact that on the borders of the ocean there are frequent sea mists which veil the sun. Thus the countries situated near the western coast of Europe have summers somewhat less hot and winters rather less cold than the countries situated in the interior of the continent in the same latitude. Hence the climates have been distinguished as equal or marine climates, and continental or excessive climates.

If the explanation which we have given of the inclination of the isothermal lines towards the equator in the interior of the continent be true, it is evident that the isochimenal lines (ἴσος equal, χειμων winter) should, for a certain extent of their course, be perpendicular, or nearly so, to the direction of the southwest wind—that is to say, to the direction of the wind pre-eminently a rainy one. Now this is in reality the case. The number of observations is not yet sufficiently great to enable us to trace these curves with exactness; but they suffice to show the general direction of several of them. If we take, for instance, the localities at which the mean temperature of winter varies between −1° and −1° 5, we find that this isochimenal line passes successively by Odessa, Dantwig, Lund in Denmark and Ullensvang in Norway. This curve extends, therefore, in latitude from 46° 28 to 60° 20; it thus traverses 14 degrees of latitude and is almost perfectly perpendicular to the direction of the southwest wind. The same is very nearly the case with other isochimenal curves; they all decline strongly towards the south in proportion as they withdraw from the western coast of Europe in advancing eastwardly into the interior of the continent.

It may be proper in addition to cite Venice, Paris, and Edinburgh; the first is situated in 45° 26 of latitude, the second in 48° 50, the third in 55° 57. Now, in these three cities the mean temperature of winter is very nearly the same; at Venice and Paris it is +3° 3, and at Edinburgh +3° 6.

Sometimes, as the sequel of abundant rains, and especially tempestuous rains, a decided lowering of the temperature is observed. This fact, at first glance, seems in contradiction with the theory of isothermal curves which we have propounded; yet it is by no means so. Almost always after a storm the sky grows clear, if only for a few hours; the air of the middle and interior regions, unburdened of the great masses of vapor which have been precipitated in the form of rain, then presents a certain degree of relative dryness; the earth, on the contrary, is soaked with rain; there takes place, therefore, at its surface an extremely abundant evaporation, which withdraws in a few instants a considerable quantity of heat from the earth and the air in contact with it. It is this subtraction of caloric which produces the cold in question.

The temperature indicated by the thermometer, moreover, is not always in accord-

ance with the sensation experienced by living beings. Often, in fact, individuals realize a much sharper cold or intense heat than the thermometer seems to verify; this depends evidently on the hygrometric condition of the air. In its natural state the body of man is always covered with a film of humidity, an insensible transpiration. If the air is calm and saturated with humidity there will be no evaporation on the surface, and complaint will be made of oppressive heat; if, on the contrary, the air is dry and agitated by the wind, the evaporation will be considerable, and a disagreeable sensation of cold will be complained of, altogether disproportioned to the thermometric indications.

Before concluding this section a word should be said of the effect of denuding mountains of their trees on the annual mean quantity of rain, on its distribution, and consequently on the climate. This influence, long denied, is now everywhere admitted—facts speak loudly enough for that. As to the explanation, we shall endeavor to give it.

The clouds which are in the middle region of the atmosphere are almost always resinous. As long as their electric tension is moderate and inferior to the tension of the earth, this latter repels them and keeps them at a greater height than comports with their specific gravity. When these clouds pass above naked and woodless mountains, inasmuch as the mountains more nearly approach them, the action in question is more efficacious, and the clouds are forced to ascend somewhat higher in consequence of the energetic repulsion exerted by the mountains. In this case the clouds pass without a discharge of rain. If, on the contrary, the clouds have a considerable electric tension, this tension is more powerful than that of the earth. When, therefore, these clouds pass over mountains destitute of trees, their resinous electricity represses the resinous electricity of the mountains into the interior of the soil, decomposes a portion of their natural electricity, and attracts the vitreous to the surface. The phenomena of repulsion are then changed into the phenomena of attraction, and the cloud is wholly precipitated, and that with violence, upon the mountain.

When the country is mountainous and wooded, the occurrence is quite different. I have already said that vapors, transparent or opaque, were kept at distance by two forces, heat and electricity; that all the phenomena which diminished by their action one or the other of these two forces, induced indirectly the condensation of the vapors, and consequently the precipitation of a part of them. These principles are directly applicable to the question with which we are engaged. When masses of transparent or opaque vapors, charged with resinous electricity, pass above wooded mountains, the vitreous electricity developed by influence in the soil flows off by the trees, which furnish thousands of points, and neutralizes a part of the resinous electricity of the super-jacent masses of vapor. The vapors, being less repelled, draw together and are condensed, the transparent vapors into opaque vapors, and these into drops of rain which fall in a regular manner and in measure proportionate to their formation.

In sum, then, the cloud, in the case of mountains naked and divested of wood, either passes without discharge or is precipitated in its entire mass; the result is an incessant oscillation from great drought to deluges of rain; in wooded mountains, on the contrary, the rains are gentle and continuous. From this we may see that to denude mountains of their woods does not perhaps diminish the annual quantity of rain, but that it modifies the distribution of the rain, or, to speak with more exactness, its mode of precipitation.

THE ROYAL INSTITUTION OF GREAT BRITAIN.

BY ED. MAILLY.

[TRANSLATED BY C. A. ALEXANDER FOR THE SMITHSONIAN INSTITUTION.*]

I.—COUNT RUMFORD, PRINCIPAL FOUNDER OF THE ROYAL INSTITUTION.

"The Royal Institution of London," says Cuvier, in his *Eloge historique* of Count Rumford, "enjoys an unsurpassed reputation as an establishment for promoting the progress of the sciences and their application to public utility." In proceeding to give some account of the Institution, it is deemed proper to prefix a few words respecting the distinguished man to whom it was chiefly indebted for its origin.

Benjamin Thompson, afterwards known as Count Rumford, was born in 1753, in the English colonies of North America, at a place then called Rumford, but now Concord. Devoted at an early age to the study of science, he adopted the profession of teacher for a livelihood, but, by an advantageous marriage, when scarcely more than 19 years old, he secured for himself entire independence in his pursuits. He had accepted the grade of major in the militia of his native province when the war of the Revolution broke out, and was led by the connections of family and personal predilection to take the part of the royal government. He served with courage and address, and after the evacuation of Boston by the British troops in 1776, was sent with important despatches to London, where he acquired the confidence of Lord George Germaine, secretary of state for the colonies, and was by him attached to that department of the public service. In 1780, Mr. Thompson was advanced to the post of under-secretary of state, but the disasters of the royal army, the constant object of his solicitude and activity, continuing to accumulate, the young minister "felt that he could not serve with honor a sinking cause, without serving it at the peril of his life."† Having raised a regiment of dragoons in America, he proceeded to take command of it and distinguished himself in several affairs. At the cessation of hostilities, he returned to England and was knighted by the King, eventually obtaining permission to enter the service of Charles Theodore, elector of Bavaria, by whom he was soon received into favor.

Sir Benjamin Thompson (which was the title he bore on his arrival at Munich, in 1784) became successively aide-de-camp, chamberlain, and privy councillor to the elector; was created lieutenant general of his armies; and when, on the death of the Emperor Joseph II, Charles Theodore was called to the functions of vicar of the empire, the latter promptly took advantage of the prerogative attached to that position to advance his favorite to the dignity of Count, giving him the title of his native village in New Hampshire.

Count Rumford passed 14 years at the court of Munich; charged at once with

* From the *Annuaire de l'Observatoire Royal de Bruxelles, par A. Quetelet, directeur de cet établissement, &c., &c.*

† G. Cuvier, *Éloge Historique du Comte de Rumford.*

the administration of war and the direction of the police, he applied himself, on the one hand, to the melioration of the condition of the soldier, and, on the other, to the suppression of mendicity by organizing a house of labor for the poor. He had never lost sight of the sciences, his earliest predilection. Researches on the cohesion of bodies and on the force of powder had procured his admission, in 1779, into the Royal Society of London. In his new position he undertook experiments on the nature of heat and light, as well as on the laws of their propagation, with a view to supplying large assemblages of persons with economical nourishment, clothing, warmth, and artificial illumination. It is not within the scope of this paper to discuss these researches of Count Rumford; they will be found detailed in his *Essays*.* Suffice it to say that light and heat became the engrossing subjects of his philosophic attention. Thus we find him, in 1796, establishing a prize at London "for new discoveries tending to the improvement of the theories regarding fire, heat, light, and colors, and for the inventions and processes by which the production, preservation, and employment of heat and light may be facilitated."†

In 1798 he proceeded to London as minister plenipotentiary of the elector of Bavaria, but was held to be disqualified for fulfilling the functions of that office by the fact of his being still regarded, in point of law, as a British subject, and incapable, therefore, of representing a foreign power at the British court. Soon afterwards he learned the death of the prince, his benefactor, and, foreseeing that he would have scarcely less difficulty in resuming his old than in exercising his new functions,‡ he turned with habitual earnestness to other pursuits, and, in becoming the principal founder of the Royal Institution, of which his favorite ideas formed the basis, established one of his best claims to lasting remembrance.

The latter years of Count Rumford were passed in retirement. In 1802 he transferred his residence to Paris, where he contracted a second marriage, with the widow of Lavoisier. This union proved unhappy, and was terminated after three years by a private separation. He then retired to a country house at Auteuil, about four miles from Paris, and there devoted his time to the embellishment of his domain, and to the cultivation of chemistry and experimental philosophy. Here he died, August 21, 1814, at the age of sixty-one years.

II.—The first prospectus of the Royal Institution.

The first meeting of the founders and directors of the Institution took place the 9th of March, 1799, at the mansion of Sir Joseph Banks, those present being Sir Joseph, the earls of Morton and Spencer, Count Rumford, Richard Clark and Thomas Bernard. Sir Joseph was named president, and Thomas Bernard secretary. The prospectus of the establishment, for the preparation of which Count Rumford was designated, bore the following title: "Proposals for forming, by subscription in the metropolis of the British empire, a public institution for diffusing the knowledge and facilitating the general introduction of useful mechanical inventions and improvements; and for teaching, by courses of philosophical lectures and experiments, the application of science to the common purposes of life—by Benjamin, Count Rumford, F. R. S.," &c.; in octavo, 54 pp.; Cadell & Davies, 1799.

The following extract from the prospectus, given by the *Bibliothéque Britanique* (sciences and arts) of Geneva, for the year last mentioned, will convey an idea of the objects of the new establishment:

When the directors shall have chosen a site, there shall be prepared large and airy apartments to receive and exhibit the mechanical inventions and improvements which seem to

* See also the *Éloge* by the Baron Cuvier, already referred to.

† See the *History of the Royal Society of London*. Count Rumford founded a similar prize at Philadelphia, United States.

‡ The new elector, Maximilian Joseph, conferred on him a pension of 30,000 francs.

improvements which seem to merit public attention; and more especially such kinds of apparatus as tend to multiply the conveniences of life; to promote domestic economy; to form the taste and facilitate the exercise of useful industry. Efforts shall be made to procure the most perfect models for each object. The following will deserve particular attention: Chimneys for cottages, with appropriate utensils; complete kitchen for a farm-house, with all its furnishings; complete kitchen, suitable for a family in easy circumstances; rooms for washing, drying, and ironing clothes for a rich family or hospital, with boilers and other necessary utensils; German, Swedish, and Russian stoves for heating apartments and passages.

"In order that those who visit the establishment may acquire just ideas of these different inventions, and of the circumstances which constitute the particular merit of each of them, *working* models shall, as far as possible, be used for exhibition; and it is evident that the greater part of those just spoken of are susceptible of being presented in that form. In the different apartments, chimneys contrived on the best principles shall be provided, to serve as models for constructors, and fires shall be constantly kept burning therein during cold weather. In the same apartments, models of grates, adapted both for ornament and economy, shall be exhibited, as well as models of ornamental stoves, in the form of elegant chimney-places, for large saloons, dining-rooms, &c.

"It is proposed also to introduce small models (though such still as shall be capable of being put in operation) of that curious and useful machine, the steam-engine; models also of the apparatus for brewing, with improved furnaces; of large stills, with the new condensers; of extensive ranges for the kitchens of hospitals and the marine, with improved fire-places. Place should be found likewise for models of ventilators for renewing the air of apartments and the interior of ships; of hot-houses, with all the known improvements; of lime-kilns of divers construction; of steam-boilers for preparing the food of domestic animals; of rustic houses, upon different plans; of wheels for spinning, and looms for the production of fabrics especially suited for the poor, and calculated to furnish them employment at home; together with models of all the new inventions proper to promote the advancement of agriculture; those of bridges, constructed on various principles; and, in fine, of all that the directors shall deem deserving of public attention in point of utility and convenience. Each article shall be accompanied by a detailed description, and exact drawings, and a designation be given of the name and abode of the artist engaged in its production, with the price of his work.

"In order to realize the second object of the Institution, that, namely, of showing the application of science to the different requirements of life, a course of public lectures on natural philosophy, accompanied by experiments, shall be established. For the use of this course there shall be a cabinet of physics and a laboratory of chemistry.

"Among the different subjects treated of in these lectures, particular attention should be given to that of heat in its application to the various uses of life; combustion, and the relative quantities of heat furnished by different combustibles; the management and economy of fire; the causes on which depends the heat of different substances used for clothing; the effects of heat and cold, both in a stationary and circulating atmosphere, upon the human body, whether in a state of health or sickness; the effects of vitiated and confined air on respiration; the means of rendering ordinary dwellings agreeable and healthy; the construction of ice-houses and preservation of ice in summer; the prevention of ailments in different seasons and climates; the cooling of liquids without the use of ice, &c.

"Vegetation and the effects of different manures, with the method of preparing and adapting the latter to various soils, should receive attention; also the changes which alimentary substances undergo in the different processes of cook-

ing, as well as in those of digestion; the chemical principles involved in the tanning of leather, with the objects to which artisans, who may seek to perfect so important a process, should direct their efforts; the chemical prinicples of the art of making soap, of bleaching, of dyeing, and, in general, of all the mechanical arts which bear a relation, more or less direct, to manufactures.

"There shall be five classes of contributors: 1, subscribers at 50 guineas, payable once for all; 2, subscribers at 10 guineas, likewise payable but once; 3, subscribers at two guineas; 4, testators or benefactors; 5, persons who pay the ticket of admission. Of these, the first class are the proprietors of the establishment. They alone elect the *directors* and *visitors*, and can alone exercise office. The establishment will be gratuitously conducted by nine directors. There shall be also nine visitors."

"Such an institution," adds the editor of the *Bibliothéque Britannique*, "is calculated to form an epoch in the history of civilization." In the month of July, 1799, there were already 138 subscribers at 50 guineas a head, 103 at 10 guineas, and 97 at two guineas. The capital of the society, therefore, was at that time 7,950 guineas, besides 194 guineas contributed by annual subscription. The first meeting of the proprietors had taken place April 20 previous.

III.—Situation of the establishment at the beginning of 1800—Dr. Garnett, the first professor of natural philosophy.

The charter of the new corporation, which by permission of George III had assumed the title of Royal Institution of Great Britain, bears date January 15, 1800. It was published with a new prospectus, mainly of a descriptive character; the indefatigable activity of Count Rumford having hastened the execution of the ideas contained in his first appeal to the public. It is here said:

* * * "The tardiness with which improvements of every kind are introduced, even such as are of the most evident utility, is a remarkable fact; it stands in striking contrast with the avidity of the public in adopting the frivolous changes created by caprice or folly, and which circulate in society under the auspices of fashion. * * * The Royal Institution has two principal objects: one, to spread promptly and introduce into all the ramifications of society a knowledge of inventions and useful improvements, drawn from the experience and practice of all nations; the other, to make known the applications of which scientific discoveries are susceptible, to the advantage of the arts and manufactures of this country, and the augmentation of domestic enjoyment and convenience. * * * The directors have purchased (June, 1799) a commodious and spacious edifice on Albemarle street, where large and airy apartments are in course of preparation for exhibiting such mechanical inventions or improvements as may be thought to merit public attention. Particularly will those inventions be exemplified which tend to increase domestic comfort and economy, to improve the taste, or advance the industry directed towards objects of utility.

"An amphitheatre will be arranged for lectures and demonstrations, accompanied by a laboratory and complete collection of instruments of experimental physics and chemistry. This branch of instruction will be confided to savants of the highest merit. * * * A place has been provisionally prepared in which three courses are given: First, a course of natural philosophy on the principles of astronomy, electricity, magnetism, mechanics, hydrostatics, pneumatics, and optics. The meetings take place every Tuesday, at 2 o'clock, and this course is particularly directed to the instruction and amusement of persons who, without having leisure or opportunity to explore thoroughly these different branches of natural knowledge, still desire to know whatever most strongly provokes curiosity. Second, a course of chemistry and its application to the arts, to manufactures, and the requirements of life. The meetings take place Wednesdays at 2 o'clock. Third, a complete and scientific course of experi-

mental physics, in which the propositions are first demonstrated mathematically, afterwards illustrated by experiments, and finally applied to the various uses of the arts and domestic economy. The meetings occur three days in the week, at 8 o'clock in the evening."

The professor who had charge of this course was Dr. Garnett. In Nicholson's journal it is said, under the date of April 1, 1800: "The course of physics and of chemistry opened by Dr. Garnett, in the apartments of the Royal Institution, is followed with the most marked attention by a numerous and distinguished auditory."

Thomas Garnett was born in 1765 or 1766, at Casterton, in Westmoreland. He received the degree of doctor of medicine at Edinburgh, in 1788, and practiced his art successfully at London, at Bradford, at Knaresborough, and at Liverpool. Called in 1796 to Glasgow to teach chemistry, he afterwards quitted that city in order to occupy at the Royal Institution the chair which had been offered him by Count Rumford. Dr. Garnett died at London June 28, 1802, in the prime of life. We owe to him a compendium entitled, Outlines of a Course of Lectures on Chemistry, Delivered at the Royal Institution of Great Britain.—*London*, 1801.

IV.—The situation of the establishment in May, 1801, and April, 1802.

To M. Pictet, one of the editors of the *Bibliothéque Britannique*, who visited London in 1801, we owe the following notices of a report made by Count Rumford to the directors and visitors of the Institution, in the month of May in that year:

"The sums subscribed for the execution of the proposed plans amount at present to £23,000, without comprising £7,000 generously offered by a small number of the proprietors (which subvention will, however, not be needed) to supply deficiencies in the cost of new buildings. Those already acquired are very extensive. The ground on which the principal edifice stands was originally occupied by four private dwellings, and the location is central to that part of London to whose inhabitants the establishment most naturally appeals for an enlightened interest, *(Albemarle street, Piccadilly.)* Professors and demonstrators in physics, chemistry, and mechanics have been engaged, and lectures are given in two spacious amphitheatres, one of which will contain 300, the other 900 persons. An ample laboratory having been provided, a manager and operator have been nominated, and negotiations are on foot with a skilful German chemist to serve as assistant to those two individuals. Shops for the construction of models, furnished with the most complete assortment of tools that could be procured, have been placed in order, under a master-workman, who will have charge of all the physical apparatus pertaining to the Institution. The operatives engaged are: a mathematical instrument maker, a constructor of models, a cabinet maker, a carpenter, a workman in brass and copper, another in tin, and still another in sheet iron. To these will be added a brick maker and mason, who will be instructed and rendered competent to instruct other workmen in the art of constructing chimneys, ovens, furnaces, &c., upon the principles recently applied to the management of fire and the economy of fuel.

"There has been established in the apartment of the janitor a complete kitchen suitable for a family of small means, with an oven for roasting of the most simple construction, a chimney place adapted to cottages, a steaming kettle, &c. All these objects are open to the inspection of those who frequent the Institution. It is proposed also to establish a principal kitchen, which shall be rendered as complete as possible in every particular. It will include ovens for baking, others for roasting, steam boilers of every construction; and in order that every one may learn to avail himself of this diversified apparatus daily use will be made of it in the Institution, and certain persons be specially charged with showing

it. And in order that the proprietors and subscribers may be enabled to judge, by experience, of the merit of such or such method of cooking, or of any new viand which may be suggested, a dining-room has been provided at the Institution, in which the directors will, from time to time, prescribe *experimental dinners*, of which the proprietors and subscribers shall be invited to partake, the whole at the expense of the guests.

"A *conversation-saloon* has been provided. * * * One of the divisions on the ground floor has been assigned for a printing-office, which pertains exclusively to the Institution. It is particularly designed for printing its journals,* which will probably be issued once a week, and of which three numbers have already appeared. These memoirs will contain not only the detail of all that is done at the Institution and in England relative to the introduction of inventions or useful improvements, but also a selection from everything of foreign production which can be of advantage to the country. * * * As the principal object of the establishment is to promote improvements in the mechanical arts, to stimulate and encourage the exercise of genius and industry, bearing on objects of practical and immediate utility, it has been decided to introduce nothing which has reference to the three *learned professions:* theology, law, and medicine.

"A department will shortly be arranged for the accommodation of 18 or 20 young persons destined for different mechanical professions. An evening school will be established with this view, in which will be taught the art of designing, practical geometry, and the elements of mathematics."

We are indebted to the *Bibliothéque Britannique* (vol. xx, 1802) for the statements which follow, taken from the report of Count Rumford, April 26, 1802:

"The new amphitheatre, where the lectures are given, is finished; notwithstanding its large dimensions, a voice uttered in a low tone can be heard from one extremity to the other, and neither echo nor resonance is remarked when a high tone is employed. Light is admitted from above by means of a cylindrical lantern of double glass, and complete obscurity is obtained by lowering the movable top of this lantern to the level of the ceiling. The saloon is of a semi-circular form, with the addition of a parallelogram equal in length to the diameter of the circular part (60 feet) and 15 feet in width. Eleven ranges of seats ascend from the floor to a gallery which contains three additional ranges. The amphitheatre is warmed in winter by steam, which is made to circulate in tubes of copper conducted under the first range of benches. * * * The depot of models is a saloon 44 feet long by 33 wide, and comprises a large number of new and useful mechanical inventions. * * * The chemical laboratory is finished, as are likewise the workshops, which are all in activity. The great kitchen is in operation, and is furnished with a complete battery. * * The price of subscription has been considerably advanced, so that while the expenditure amounts to but £3,894, (97,350 francs,) the receipts have risen to £8,484, (212,000 francs.) The Royal Institution may thus be considered as completed and firmly established."

V.—The engagement of Humphrey Davy.

From what has been said above, we may form an exact idea of the plan which had been proposed by Count Rumford in creating the Royal Institution. This plan, however, was destined soon to undergo essential modifications, and nothing more greatly contributed to the change than the engagement of Humphrey Davy by Rumford himself.

Mr. Underwood and Dr. Hope (their names deserve commemoration) having spoken in the most eulogistic terms of the young chemist of Penzance, Count Rumford entered into negotiations with Davy in January, 1801, and, 16th Feb-

*Journals of the Royal Institution of Great Britain.

ruary following, the future president of the Royal Society of London was enrolled in the service of the Institution as assistant professor of chemistry, director of the laboratory, and joint editor of the journals of the establishment. The proceedings of the directors import that he should be allowed to occupy a room in the house, be furnished with coals and candles, and be paid a salary of 100 guineas a year.*

Davy arrived in London the 11th of March. His first lecture completely justified the expectations of his patrons, nor was he long in becoming extremely popular through his natural eloquence, his chemical acquirements, and the success which crowned all his experiments. His first interview with Rumford, it would seem, had not been favorable. At the almost childish appearance of the candidate, his rather provincial manner, accompanied by some remains of the Cornish dialect, Count Rumford, who did not shine in point of affability, became more frozen than usual; it was with difficulty that Davy obtained leave to give, in a private apartment of the house, a few lectures on the properties of gases; but he needed nothing more. "From the first, the variety of his ideas, their ingenious combinations, the warmth, the vivacity, the perspicuity, even the novelty of their mode of statement, all the charms that the combined talents of the poet, the orator, and the philosopher could lend to the instructions of the chemist, enchanted the small number of those who had ventured to come and hear him. With so much enthusiasm did they speak of him that at the second lecture the room which had been assigned him could not contain the throng which presented itself, and it was necessary to transfer his course to the great amphitheatre of the establishment. The youthfulness of a professor just emerging from adolescence, his handsome face, his ingenuous manner, scarcely contributed less than his eloquence to conciliate affection." (Cuvier, *Eloge Historique, &c.*)

Davy (born December 17, 1778, at Penzance, a small town of Cornwall) was then 22 years of age. Son of a carver in wood, he had early entered, as apprentice, the office of a skilful surgeon of his native place, who at the same time conducted a pharmaceutical establishment. It was Davy's intention to become a physician, but the plan of study which he had traced for himself embraced seven languages, from English to Hebrew, and all the moral and physical sciences, from theology and astronomy to rhetoric and mechanics. It is somewhat remarkable that he does not seem to have seriously occupied himself with chemistry until he had attained his 19th year. From that time he devoted himself to it with all the ardor of his temperament; and his eldest sister, who lent her services to assist him, well remembered the damage sustained by her dresses from corrosive substances. (Paris, *Life of Davy.*)

His resources were very limited, like those of Priestley and Scheele at their entrance upon the same career. His apparatus consisted principally of phials, wine glasses, tea cups, tobacco pipes, and earthen pipkins, and his materials were chiefly the mineral acids, the alkalies, and some other articles of which use is made in medicine. He commenced his experiments in his sleeping-room, and when he had need of fire, descended with his vessels to the kitchen. (*Memoirs of the Life of Sir Humphrey Davy*, by his brother, John Davy, London, 1836.) A shipwreck which occurred on the coast procured him some unexpected resources. He had the good luck to lay hands on a box of surgical instruments. Among them there happened to be a common syringe; of this he constructed an air pump! "During his whole life," says Cuvier, "he continued to make use of everything that came to hand in the service of his researches; and the simplicity of his apparatus was not less remarkable than the originality of his experiments and the elevation of his views."

* It was the intention of Count Rumford to try Davy as professor, and to give him the succession of Dr. Garnett, whose services the Institution was on the point of losing. "Little accommodating in his disposition, Count Rumford had already broken with his professor of chemistry, Dr. Garnett." (G. Cuvier, *Eloge Historique de Sir Humphrey Davy.*)

Dr. Beddoes, having founded at Bristol an establishment (the Pneumatic Institution) where the therapeutic properties of the gases might be carefully studied and turned to account, had need of an assistant. On the recommendation of Davies Gilbert (who presided over the Royal Society of London from 1827 to 1830) he made choice of the young Davy, whose merit he could well appreciate from a memoir which the latter had sent him for insertion in a journal which he edited. Davy left for Bristol October 2, 1798, and, the year following, he there discovered the properties of nitrous oxide gas, (protoxide of nitrogen,) a discovery which rendered his name popular in the three kingdoms.

VI.—The first course of chemistry given by Davy.—The discoveries made by him in the laboratory of the Institution.

We have shown how Davy had entered the Royal Institution and the success which he there attained as professor. His lectures took place on Thursdays at 2 and 8 o'clock in the afternoon, and on Saturdays at 2. The earlier lectures of the afternoon were devoted to general chemistry, those of the evening to its applications. The abstract of his first course has been preserved;* it was divided into three parts: the chemistry of ponderable substances; the chemistry of imponderable substances; the chemistry of the arts.

The first of these parts treats: (1) of chemical forces and their modes of application; (2) of uncompounded substances or simple principles; (3) of bodies compounded of two simple substances; (4) of bodies compounded of more than two simple substances; (5) of substances compounded of different compound bodies and of simple bodies; (6) of the general phenomena of chemical action. The second part treats: (1) of heat or caloric; (2) of light; (3) of electrical influence; (4) of galvanism. The third part treats: (1) of agriculture; (2) of tanning; (3) of bleaching; (4) of dyeing; (5) of metallurgy; (6) of the manufacture of glass and porcelain; (7) of the preparation of solid and liquid aliments; (8) of the employment of artificial heat and light.

Nominated to the incumbency of the chair of chemistry May 31, 1802, Davy resigned it April 5, 1813. He had given his last lecture April 9, 1812, the day after that on which he had been knighted by the prince regent, and the eve of his nuptials with Mrs. Apreece, a union which made him master of a large fortune. He had shed great lustre on the Royal Institution, at the same time that he changed the character which had pervaded the thought of its founder. The Institution was no longer a school of arts and trades, established with a view to the most numerous class of society, but redounded almost exclusively to the profit of the higher classes. "Ladies of the highest rank," says Cuvier, "followed his lectures, together with lords of high degree, and the most distinguished of the young men." The spirit of research was introduced, and the laboratory of the Institution became the theatre of the most brilliant discoveries. It was there that Davy discovered the laws of electro-chemical decomposition; succeeded in decomposing the fixed alkalies, established the true nature of chlorine, and the philosophy of flame. The electric battery with which the separation of potassium and of sodium was effected, and which is still preserved in the establishment with other apparatus used by Davy, consisted of three batteries combined, one of 24 square plates of copper and zinc, of 12 inches to the side, another of 100 plates of six inches, and the third of 150 plates of four inches. The discovery of potassium was made October 6, 1807. The pleasure which Davy experienced at seeing the small globules of the new metal spring through the crust of potash and kindle on contact with the air was witnessed by his relative and assistant, Edmund Davy. "Our professor could not restrain

* *A Syllabus of a Course of Lectures on Chemistry, delivered at the Royal Institution of Great Britain*, by H. Davy, professor of chemistry, pp. 91, octavo, London, Cadell & Davies, 1802.

his delight, and began dancing around the room in a transport of joy, and it was some time before he recovered sufficient composure to continue the experiment." The directors and principal members of the institution afterwards caused a galvanic battery of 600 pairs of four-inch plates to be constructed, and this again was replaced by a battery of 2,000 pairs. This powerful artillery was directed against the earths, and the new metals received the names of barium, strontium, calcium, and magnesium, after the names of the earths from which they were separated.

The limits which we have prescribed to ourselves do not permit us to follow Davy after his retirement from the Institution. "If I relinquish teaching," he wrote to his brother at the time of his marriage, "it is solely with the purpose of having more time to devote to original researches and to the advancement of the great objects of science." But from 1812 his life was essentially that of a traveller and man of the world; he was created baronet in 1818, three years after the discovery of the safety-lamp,* and died at Geneva May 29, 1829.

VII.—Nomination of Dr. Young to the Chair of Natural Philosophy.

Towards the close of 1801 the directors of the Royal Institution nominated to the chair of natural philosophy (physics and mechanics) a man of perhaps still greater genius than Davy, the celebrated Dr. Young.

Thomas Young was born at Milverton, in Somersetshire, June 13, 1773. He was an infant prodigy. At two years of age he could read fluently; at four he could recite from memory a great number of English writers and even Latin poems, of which, however, he understood not a word. From nine to fourteen he learned, besides Greek and Latin, the French, Italian, Hebrew, Persic, and Arabic languages; "French and Italian, incidentally, for the purpose of satisfying the curiosity of a comrade who had in his possession several works printed at Paris, whose contents he was desirous of knowing; Hebrew, in order to read the Bible in the original; Persic and Arabic, with a view to the decision of the question, which had arisen in a conversation at table, whether differences exist between the oriental languages as marked as those which exist between European languages." (Arago, *Biography of Thomas Young.*) His passion for knowledge was unbounded, and no obstacles stopped him in its pursuit. Having seen a land-surveyor at work, when he was scarcely eight years old, he applied himself to learn, by means of a dictionary of mathematics, the nature of the operations, and soon qualified himself to make the calculations. Still later, he conceives an ardent taste for botany, and undertakes to construct a microscope. For that purpose he must first know the theory of the instrument; and, as he has at hand nothing but a book bristling with analytic formulas, he studies the differential calculus in order to comprehend it, and, between times, acquires great skill in the art of turnery. His favorite maxim was, that *every man may do what any other man has done.* While he was prosecuting his medical studies in Edinburgh, which had been commenced in London, he acquired so much skill in funambulism as to compete with a famous professor of the art; and at Göttingen, where he passed nine months, and where he received the degree of doctor of medicine, he attained extraordinary dexterity as a vaulter on horseback. Profoundly versed in the theory of music, he also cultivated his powers

* See the *History of the Royal Society of London*, where will be found other details respecting Davy, and, among the rest, respecting the mortification which he sustained in relation to certain means he had proposed for preventing the corrosion of the copper with which vessels are lined. I add an extract from a letter, which he wrote on this occasion to Mr. Children: "A mind of much sensibility might be disgusted, and one might be led to say: Why labor for the public interest, when the sole recompense is abuse? They have irritated me more than I should have been, but I become wiser day by day, calling to remembrance Galileo and the time when the philosophers and benefactors of society obtained no other recompense for their services but the stake."

of execution to such an extent that Arago says of him in the biography before cited: "Of all known instruments, including even the Scotch bagpipe, it seems certain that there were but two on which he could not perform." His brilliant discoveries in physics are well known. In 1818, the illustrious author of the doctrine of *interferences of light*, having been nominated secretary of the bureau of longitudes, and charged with the superintendence of the Nautical Almanac, turned his attention to astronomy, and abandoned almost entirely the practice of medicine. As a physician his services had never been in any great request. He was suspected of being too learned, and, in truth, "notwithstanding his knowledge, or, perhaps, even by reason of its vast extent, he was wholly deficient in confidence at the bedside of the sick."*

In a notice of the Nautical Almanac, I have mentioned the vexations which he incurred as astronomer, and I shall not here return to the subject.

Dr. Young died May 10, 1829; nineteen days, consequently, before his former colleague, Sir Humphrey Davy.

VIII.—The introductory lecture of Dr. Young.

We shall here consider Dr. Young only as regards his connection with the Royal Institution. This connection was of no long continuance. His first lecture was given January 20, 1802, and he retired after having filled the professorship two years. If we are to believe the author of his life in the *Biographie Universelle* of the brothers Michaud, he had not been popular. He was reproached with being too laconic, with not giving sufficient development to his explanations, with want of clearness. But the learned world owes to his connection with the Institution a work of the highest order, which appeared in 1807, under the title of "*A Course of Lectures on Natural Philosophy and the Mechanical Arts*," by Thomas Young, M. D., &c.; 2 vols. quarto, comprising together 1,570 pages and 58 plates.†

The first lecture, which serves as an introduction to the course, possesses so high an interest that we deem it due to our readers to place it, at least in part, before their eyes; there is always something to be gained by knowing and reflecting on the ideas of a man of genius:

"It is to be presumed that the greater part of those who honor with their attendance the amphitheatre of the Royal Institution, already know the nature of the objects which its founders and promoters have been endeavoring to attain; yet it would seem by no means superfluous that I should define with accuracy my own views of the utility which is likely to be derived from it and the most effectual means of accomplishing its purposes, in order that we may discover more easily the best route to be pursued in our common progress through the regions of science, and that those who are desirous of accompanying me may know precisely what path we mean to follow, and what departments will more particularly arrest our attention. * * * The primary and peculiar object of the Institution is to apply to domestic convenience the improvements which have been made in science, and to introduce into general practice such mechanical inventions as are of decided utility. But, while it is chiefly engaged in this pursuit, it extends its views, in some measure, to the promotion of the same ends which pertain to the special province of other literary societies; and it is the more impossible that these objects should be wholly excluded, as it is upon

* *Biography by Arago.*—"No study," said Dr. Young, "is so complicated as that of medicine. It surpasses the bounds of human intelligence. Physicians who proceed without attempting to comprehend what is before them, often see as far as those who place reliance in hasty generalizations, based upon observations in regard to which all analogy is in default."

† Young had published, at the commencement of 1802, a programme of the lectures which he proposed to deliver at the Royal Institution, under the title of "*A Syllabus of Lectures on Natural and Experimental Philosophy*," in a quarto volume of 193 pages.

the advancement of these that the specific objects of the Institution must ultimately depend. It follows that the dissemination of physical and chemical knowledge becomes a truly essential part of the design of the Royal Institution; and this department must, in the natural order of arrangement, be anterior to the application of the sciences to practical uses. To exclude all knowledge except that which has been already applied to immediate utility, would be to reduce our faculties to a state of servitude, and to frustrate the very purposes which we are laboring to accomplish. No discovery, however remote in its nature from the subjects of daily observation, can with reason be pronounced wholly inapplicable to the benefit of mankind.

"It has seemed to me, therefore, to be not only the best beginning, but also an object of high and permanent importance in the plan of the Royal Institution, to direct public attention to the cultivation of the elementary doctrines of natural philosophy, as well speculative as practical. Those who possess the genuine spirit of scientific investigation, and who have tasted the pure satisfaction arising from an advancement in intellectual acquirements, are contented to proceed in their researches, without inquiring at every step what they gain by their newly discovered lights, and to what practical purposes they are applicable; they receive a sufficient gratification from the enlargement of their views of the constitution of the universe, and experience, in the immediate pursuit of knowledge, that pleasure which others wish to attain more circuitously by its means. And it is one of the principal advantages of a liberal education, that it creates a susceptibility of an enjoyment so elegant and so rational.

"A considerable portion of my audience, to whose information it will be my particular ambition to accommodate my lectures, consists of that sex which, by the custom of civilized society, is in some measure exempted from the more laborious duties that occupy the time and attention of the other sex. The many leisure hours which are at the command of females in the superior orders of society, may surely be appropriated, with greater satisfaction, to the improvement of the mind and the acquisition of knowledge, than to such amusements as are only designed for facilitating the insipid consumption of superfluous time. The hours thus spent will unquestionably become, by a little habit, as much more agreeable at the moment, as they must be more capable of affording self-approbation upon reflection. And besides, like the seasoning which reconciled the Spartans to their uninviting diet, they will even heighten the relish for those pursuits which they interrupt; for mental exercise is as necessary to mental enjoyment, as corporal labor to corporal health and vigor. In this point of view, the Royal Institution may in some degree supply the place of a subordinate university to those whose sex or situation in life has denied them the advantage of an academical education in the national seminaries of learning.

"But notwithstanding the necessity of introducing very copiously speculations of a more general nature, we must not lose sight of the original objects of the Royal Institution; and we must therefore direct our attention more particularly to the theory of practical mechanics and of manufactures. In these departments we shall find some deficiencies which may, without much difficulty, be supplied from scientific principles; and by an ample collection and display of models, illustrative of machines and of inventions of all kinds, we may proceed in the most direct manner to contribute to the dissemination of that kind of knowledge which is more particularly our object. So that we must be more practical than academies of science, and more theoretical than societies for the improvement of arts; while we endeavor at the same time to give stability to our proceedings by an annual recurrence to the elementary knowledge which is subservient to both classes of institutions, and, as far as we are able, to apply to practice the newest lights which may, from time to time, be thrown on particular branches of mechanical science. It is thus that we may most effectually perform what the sophists of antiquity but verbally professed, to bring down philosophy from the heavens, and make her an inhabitant of the earth.

"To those who are engaged in the practical cultivation of various arts conducive to the conveniences of life, these lectures may be of utility by furnishing them with well-established principles, applicable to a variety of cases which may occasionally occur to them, when a little deviation from the ordinary routine of their profession may be necessary. Unfortunately, the hands that execute are too often inadequately supported by the head that directs; and much labor is lost for want of a little previous application to the fundamental doctrines of the mechanical sciences. Nor is any exorbitant portion of time or industry necessary for this purpose; for it happens that almost all practical applications of science depend on principles easily learned. * * * We may also be able to render an important service to society, and to confer a still more essential benefit on individuals, by repressing the premature zeal of unskilful inventors. We need only read over the monthly accounts of patents intended for securing the pecuniary advantages of useful discoveries, in order to be convinced what expense of time and fortune is continually lavished on the feeblest attempts to innovate and improve. If we can be successful in convincing such inconsiderate enthusiasts of their real ignorance, or if we can show them that even their own fairy ground has been preoccupied, we may save them from impending ruin, and may relieve the public from the distraction of having its attention perpetually excited by unworthy objects. The ridicule attendant on the name of a projector has been in general but too well deserved; for few, very few, who have aspired at improvement, have ever had the patience to submit their inventions to such experimental tests as common sense would suggest to an impartial observer. We may venture to affirm that out of every hundred of fancied improvements in arts or in machines, ninety at least, if not ninety-nine, are either old or useless; the object of our researches is, to enable ourselves to distinguish and adopt the hundredth. But while we prune the luxuriant hoots of youthful invention, we must remember to perform our task with lenency, and to show that we wish only to give additional vigor to the healthful branches, and not to extirpate the parent plant.

"The Repository of the Institution, as soon as it can be properly furnished, will be considered as a supplementary room for apparatus, in which the most interesting models exhibited and described in the lectures will be placed for more frequent inspection, and where a few other articles may perhaps deserve admission, which will not require so particular an explanation. To those who have profited by the lectures, or who are already too far advanced to stand in need of them, our rooms for reading and for literary conversation may be a source of mutual instruction. Our library in time must contain all those works of importance which are too expensive for the private collections of the generality of individuals, which are necessary to complete the knowledge of particular sciences, and to which references will occasionally be given in the lectures on those sciences. Our journals, free from commercial shackles, will present the public from time to time with concise accounts of the most interesting novelties in science and the useful arts; and they will furnish a perpetual incitement to their editors to appropriate, as much as possible, to their own improvement, whatever is valuable in the publications of their cotemporaries. When all the advantages which may reasonably be expected from this Institution shall be fully understood and impartially considered, it is to be hoped that few persons of liberal minds will be indifferent to its success, or unwilling to contribute to it and to participate in it.

"To that regulation which forbids the introduction of any discussions connected with the learned professions I shall always most willingly submit and most punctually attend. It requires the study of a considerable portion of a man's life to qualify him to be of use to mankind in any of them; and nothing can be more pernicious to individuals or to society than the attempting to proceed practically upon an imperfect conception of a few first principles only. In physic

the wisest can do but little, and the ignorant can only do worse than nothing; and just as anxiously as we are disposed to seek whatever relief the learned and experienced may be able to afford us, should we cautiously avoid the mischievous interference of the half-studied empiric; in politics and in religion, we need but look back on the history of kingdoms and republics, in order to be aware of the mischiefs which ensue when 'fools rush in where angels fear to tread.'"

IX.—Continuation of the Introductory Lecture.

"Deeply impressed with the importance of mathematical investigations, both for the advancement of science and for the improvement of the mind, I thought it in the first place an indispensable duty to present to the Royal Institution in my syllabus a connected system of natural philosophy, on a plan seldom if ever before executed in the most copious treatises. Proceeding from the simplest axioms of abstract mathematics, the syllabus contains a strict demonstration of every proposition which I have found it necessary to employ throughout the whole extent of natural philosophy. In the astronomical part only, some observations occur unsupported by mathematical evidence. Here, however, it was as impracticable as it would have been useless to attempt to enter into investigations, which in many instances have been extended far beyond the limits even of Newton's researches. But for the sake of those who are not disposed to undertake the labor of following, with mathematical accuracy, all the steps of the demonstrations on which the doctrines of the mechanical sciences are founded, I shall endeavor to avoid, in the whole of this course of lectures, every intricacy which might be perplexing to a beginner, and every argument which is fitter for the closet than for a public theatre. Here I propose to support the same propositions by experimental proofs; not that I consider such proofs as the most conclusive, or as more interesting to a truly philosophic mind than a deduction from general principles, but because there is a satisfaction in discovering the coincidence of theories with visible effects, and because objects of sense are of advantage in assisting the imagination to comprehend and memory to retain what, in a more abstracted form, might fail to excite sufficient attention. This combination of experimental with analogical arguments constitutes the principal merit of modern philosophy.

"With regard to the mode of delivering these lectures, I shall in general entreat my audience to pardon the formality of a written discourse in favor of the advantage of a superior degree of order and perspicuity. It would unquestionably be desirable that every syllable advanced should be rendered perfectly easy and comprehensible, even to the most uninformed; that the most inattentive might find sufficient variety and entertainment in what is submitted to them to excite their curiosity, and that in all cases the pleasing, and sometimes even the surprising, should be united with the instructive and the important. But whenever there appears to be a real impossibility of reconciling these various objects, I shall esteem it better to seek for substantial utility than temporary amusement; for if we fail of being useful for want of being sufficiently popular, we remain at least respectable; but if we are unsuccessful in our attempts to amuse, we immediately appear trifling and contemptible. It shall, however, at all times be my endeavor to avoid each extreme, and I trust that I shall then only be condemned, when I am found abstruse from ostentation or uninteresting from supineness. The most difficult thing for a teacher is to recollect how much it cost himself to learn, and to accommodate his instruction to the apprehension of the uninformed; by bearing in mind this observation, I hope to be able to render my lectures more and more intelligible and familiar; not by passing over difficulties, but by endeavoring to facilitate the task of overcoming them; and if at any time I appear to have failed in this attempt, I shall think myself honored by any subsequent inquiries that my audience may be disposed to make.

"We have to extend our views over the whole circle of natural and artificial knowledge, to consider in detail the principles and application of the philosophy of nature and of art. * * To insist on the propriety of a distinct and logical order is unnecessary; for, however superfluous we may deem the scholastic forms of rhetoric, it is confessedly advantageous to the judgment as well as to the memory to unite those things which are naturally connected, and to separate those which are essentially distinct. When a traveller is desirous of becoming acquainted with a city or country before unknown to him, he naturally begins by taking from some elevated situation a distant view of the distribution of its parts; and in the same manner, before we enter on the particular consideration of the subjects of our researches, it may be of use to form to ourselves a general idea of the sciences and arts which are to be placed among them. * * * The division of the whole course of lectures into three parts was originally suggested by the periodical succession in which the appointed hours recur; but it appears to be more convenient than any other for the regular classification of the subjects. The general doctrines of motion, and their application to all purposes variable at pleasure, supply the materials of the first two parts, of which the one treats of the motions of solid bodies, and the other of those of fluids, including the theory of light. The third part relates to the particular history of the phenomena of nature, and of the affections of bodies actually existing in the universe, independently of the art of man; comprehending astronomy, geography, and the doctrine of the properties of matter, and of the most general and powerful agents that influence it.*

"The synthetical order of proceeding, from simple and general principles to their more intricate combinations in particular cases, is by far the most compendious for conveying information with regard to sciences that are at all referable to certain fundamental laws. For these laws being once established, each fact, as soon as it is known, assumes its place in the system, and is retained in the memory by its relation to the rest as a connecting link. In the analytical mode, on the contrary, which is absolutely necessary for the first investigation of truth, we are obliged to begin by collecting a number of insulated circumstances, which lead us back by degrees to the knowledge of original principles, but which, until we arrive at those principles, are merely a burden to the memory. For the phenomena of nature resemble the scattered leaves of Sybilline prophecies; a word only or a single syllable is written on each leaf, which, when separately considered, conveys no instruction to the mind; but when by the labor of patient investigation every fragment is replaced in its appropriate connection, the whole begins at once to speak a perspicuous and harmonious language. * * *

"Before proceeding to the examination of the several parts of our plan, we must pause to consider the mode of reasoning which is the most generally to be adopted. It depends on the axiom which has always been essentially concerned in every improvement of natural philosophy, but which has been more and more employed, ever since the revival of letters, under the name of induction. That like causes produce like effects, or that in similar circumstances similar consequences ensue, is the most general and most important law of nature; it is the foundation of all analogical reasoning, and is collected from constant experience by an indispensable and unavoidable propensity of the human mind. * * * In the application of induction, the greatest caution and circumspection are necessary; for it is obvious that before we can infer with certainty the complete similarity of two events, we must be perfectly well assured that we are acquainted

* This third part should include, along with the properties of matter and the particular action of its particles, the whole of chemical science; but the variety and importance of the researches of chemistry require a separate and minute discussion, and the novelty as well as beauty of many of the experiments with which the labors of our contemporaries have enriched this branch of knowledge, and which will be repeated in the amphitheatre of the Institution by the professor of chemistry, suffices to make this part of natural philosophy the most interesting of all the sciences.

with every circumstance which can have any relation to their causes. The error of some of the ancient schools consisted principally in want of sufficient precaution in this respect; for although Bacon is with great justice considered as the author of the most correct method of induction, yet, according to his own statement, it was chiefly the guarded and gradual application of the mode of argument that he labored to introduce. He remarks that the Aristotelians, from a hasty observation of a few concurring facts, proceeded immediately to deduce universal principles of science and fundamental laws of nature, and then derived from these, by their syllogisms, all the particular cases which ought to have been made intermediate steps in the inquiry. Of such an error we may easily find a familiar instance. We observe that, in general, heavy bodies fall to the ground, unless they are supported; it was therefore concluded that all heavy bodies tend downwards; and since flame was most frequently seen to rise upwards, it was therefore inferred that flame was naturally and absolutely light. Had sufficient precaution been employed in observing the effects of fluids on falling and on floating bodies, in examining the relations of flame to the circumambient atmosphere, and in ascertaining the specific gravity of the air at different temperatures, it would readily have been discovered that the greater weight of the colder air was the cause of the ascent of the flame—flame being less heavy than air, but yet having no positive tendency to ascend. And accordingly the Epicureans, whose arguments, as far as they related to matter and motion, were often more accurate than those of their cotemporaries, had corrected this error; for we find in the second book of Lucretius a very just explanation of the phenomenon:

> "See with what force yon river's crystal stream
> Resists the weight of many a massive beam.
> To sink the wood the more we vainly toil,
> The higher it rebounds with swift recoil.
> Yet that the beam would of itself ascend
> No man will rashly venture to contend.
> Thus, too, the flame has weight, though highly rare,
> Nor mounts but when compelled by heavier air."

"It may be proper to notice here those axioms which are denominated by Newton rules of philosophizing, although it must be confessed that they render us very little immediate assistance in our investigations. The first is that 'no more causes are to be admitted as existing in nature than are at once true and sufficient for explaining the phenomena to be considered;' the second, 'therefore effects of the same kind are to be attributed, as far as possible, to the same causes;' thirdly, 'those qualities of bodies which cannot be increased nor diminished, and which are found in all bodies within the reach of our experiments, are to be considered as general qualities of all bodies existing;' fourthly, 'in experimental philosophy, propositions collected by induction from phenomena are to be esteemed either accurately or very nearly true, notwithstanding any contrary hypothesis, until other phenomena occur by which they may either be corrected or confuted.'

"As an illustration of the remark that these axioms, though strictly true, are of little real utility in assisting our investigations, I shall give an instance from the subject of electricity. Supposing that we wish to determine whether or no the electric fluid has weight, we are to inquire whether or no gravitation is one of those properties which are described in the third rule, and whether that rule will authorize us to apply it to the electric fluid as one of those qualities of bodies, which cannot be increased or diminished, which are found in all bodies within the reach of our experiments, and which are therefore to be considered as general qualities of all bodies existing. Now, it appears to be, in the first place, uncertain whether or no the increase and diminution of gravity, from a change of distance, is strictly compatible with the terms of the definition; and in the second place, we are equally at a loss to decide whether or no the electric fluid can with

propriety be called a body, for it appears in some respects to be wholly different from tangible matter, while it has other qualities in common with it. Such are the difficulties of laying down general laws on so comprehensive a scale that we shall find it more secure to be contented to proceed gradually by closer inductions in particular cases. We shall, however, be seldom much embarrassed in the choice of a mode of argumentation. The laws of motion, which will be the first immediate subject of discussion, have indeed sometimes been referred to experimental evidence, but we shall be able to deduce them all in a satisfactory manner, by means of our general axiom, from reasonings purely mathematical, which, wherever they are applicable, are unquestionably preferable to the imperfect evidence of the senses, employed in experimental investigations."

X.—Summary of Dr. Young's Course of Lectures.

A scientific publication* of that epoch takes the following notice of the work of we have just been speaking:

"When Dr. Young accepted the chair of physics in the Royal Institution, he regarded that position as demanding of him something else than a simple compilation from elementary treatises; consequently he engaged in researches among original authorities, in examining attentively and uniting in a single system all that related to the principles of mechanical science, and all that could contribute to the improvement of the useful arts. In following this plan he has reduced the fundamental doctrine of movement to simple mathematical axioms in a more immediate manner than had before been done, and he has facilitated the application of those principles to all the cases which present themselves in practice. He has investigated by a great number of experiments the force or tenacity of materials of every kind; a labor of which the results are highly important to the engineer and the architect. He has simplified, extended and elucidated the theory of the movement of waves, that of the circulation of the blood, and of the propagation of sound. He has studied the curvature of images produced by lenses and mirrors; he has examined in detail the functions of the eye, and represented in a very comprehensive and very exact manner the phenomena of colored light; he has also pointed out some new cases of the production of colors. He has reduced the theory of tides to a very simple form; and his researches on the cohesion and capillary action of fluids are anterior to those of M. de Laplace. He has made different comparative experiments on the elasticity of the steam of boiling water, on evaporation and the hygrometric indications; in fine, his work is strewn, to a large extent, with new inventions and practical applications.

"The second volume begins with the mathematical elements of the physical sciences. Here are found all the propositions requisite for forming a complete series of demonstrations applicable to all the important cases which occur in that department of scientific inquiry. The author has excluded only some of the more complex calculations of astronomy. A considerable portion of the volume is occupied by a comprehensive catalogue of works relating to physics and the arts, methodically subdivided, and accompanied with such strictures as, in the judgment of the author, were due to their respective degrees of merit.

XI.—The Course of Natural Philosophy given at the Royal Institution by Doctor Dalton.

After the retirement of Young, Dalton,† the celebrated author of the *atomic* theory, was invited to London to give a course of natural philosophy at the

* *Nicholson's Journal.* Our extract is derived from the *Bibliothéque Britannique*, t. xxxvii, No. 4, April, 1808.

† John Dalton, born September 5, 1766, at Eaglesfield, in Cumberland, died July 27, 1844, at Manchester, where he had passed his life in making chemical analyses for the manufacturers, the price of which varied from a few shillings to a sovereign, and in giving

Institution. He has himself recorded, in a letter to one of his friends, what occurred on this occasion, and the relations which he had borne to Davy. "I was presented," he says, "to Mr. Davy, whose rooms at the Royal Institution adjoin mine. He is a most agreeable and intelligent young man, and of an evening we have some interesting conversations. His chief defect, as a philosopher, is that he does not smoke. Mr. Davy advised me to spare no labor on my first lecture. He told me that the world hereabouts would be disposed to form its opinions from this introduction: consequently I resolved to *write* my first lecture throughout; to *do* nothing but give a statement of what it was my intention to undertake, and to expatiate on the importance and utility of the science. I studied and wrote for nearly two days; I then calculated, almost to a minute, the time which my lecture would occupy, adapting my discourse to a duration of 50 minutes. The day before that on which I was to deliver my lecture, Davy and I repaired, in the evening, to the amphitheatre, where I read my lecture to the end, while he remained stationed in the farthest corner; next, he read while I represented the auditory. We then discussed our respective styles. The next day I read my discourse before a company of 150 to 200 persons, which was more than had been expected. When I had finished there was general applause, and a great many of the audience came forward to compliment me. Since that occasion I have rarely written at all, relying solely on experiment and verbal explanation. In general, my experiments have been highly successful, and I have not once become embarrassed in my statements; so that now, when I enter the lecture room, I feel scarcely more concern than when I smoke a pipe with you on Sunday and Wednesday evenings." To believe, however, an eminent critic, Dalton must unconsciously have put too high an estimate on a success, of which the politeness of the audience seems to have defrayed the chief expense, and to which the simplicity and singularity of the man contributed probably more than any talent he possessed as a professor. "It would be difficult to conceive," says the writer referred to, (Quarterly Review, No. XCVI,) "anything more awkward and inadequate than his manner of treating the great physical truths before him. His experiments in public frequently failed; his delivery was dry, indistinct, and without expression, and he was far from possessing the language and power of illustration necessary to the professor who deals with the lofty themes of philosophy, and by means of which Davy and Faraday have shed so brilliant a light on their great discoveries."

Dalton survived Davy and Young, and, in 1830, was chosen to replace the former as one of the foreign associates of the French Academy of Sciences. In 1832, having gone to Oxford to be present at the meeting of the British Association, he received from the University the diploma of Doctor of Civil Law; and hence, modest and simple as he was, a man whose chief pleasures on earth were the pipe and playing at bowls, he was to be seen, for several days, invested, whenever he went abroad, with the red robe of the doctorate. He allowed himself, at the instance of Mr. Babbage, to be presented at court, and that gentleman has recounted for us all the incidents of this grand event in the life of the philosopher of Manchester. Lord Brougham, at that time Lord Chancellor, offered his services to make the presentation, and had already spoken of it to the King; but difficulties supervened. Dalton, in his quality of Quaker, could not assume the uniform of the court, which would have required him to wear a sword. It was suggested to dress him in the robe of a doctor of laws of Oxford; but red was not a color admissible by Quakers. Luckily, the sight of Dalton was of such a nature as did not enable him to distinguish colors; he labored under a sort of blindness as regards them. There remained the cap of

lessons on chemistry and mathematics, at the rate of two shillings and a half per hour when he had but one scholar, and one and a half only for each scholar when he had two or more. In 1833, the government had spontaneously granted him a pension of 150 pounds, which pension was doubled in 1836.

velvet; but he was made to observe that the cap was usually carried in the hand, and that it was rather the sign of a dignity than a covering for the head. "These difficulties being overcome," continues Mr. Babbage, "the doctor came one morning to breakfast with me. We were alone, and, after breakfast, I recited the ordinary forms of a levee, and, placing some chairs to represent the different officers of the reception room, I stationed the doctor in the midst of the circle to represent the King. I then said to my friend that I would represent a greater man than the King; that I would personate Dr. Dalton; that I would enter at the farthest door, make the tour of the circle, and bow before his Majesty; and that thus he would have an idea of the ceremony in which he was to take a part. In passing in front of the third chair, before arriving at the King, I deposited my card on the chair, apprising the doctor that this was the post of the lord in attendance who took the cards and handed them to the succeeding officer, who announces them to the King. In passing before the philosopher I kissed his hand, and, moving afterwards around the rest of the circle of chairs, I thus gave him his first lesson as a courtier." A second rehearsal having taken place, Dalton made his entrance at Saint James's in the midst of an assembly in which figured several of the high dignitaries of the Anglican church. "I intimated to the bishop of Gloucester," adds Mr. Babbage, "that I had beside me a Quaker, but at the same time assured him that my peaceable friend was far from meditating any attempt against the Church. The effect was electric on the whole party; Episcopal eyes had never witnessed such a spectacle in such a society, and I am not without apprehension that, notwithstanding my assurances, some of the prelates may have thought the Church seriously in danger." As to Dalton, he came out of the affair very creditably. The King addressed to him several questions, to which he replied without being at all disconcerted.

XII.—Course of moral philosophy by Sydney Smith.

Sydney Smith, (born 1768, died February 22, 1845,) one of the founders of the *Edinburgh Review*, whom we must not confound with the celebrated admiral of the same name, arrived in London towards the close of 1803. He quickly became noted as a preacher, and obtained great consideration in the highest society. The directors of the Institution were at that time, as they have never ceased to be, on the watch for all talents capable of reflecting lustre on their establishment; they invited Smith to give a course of moral philosophy, embracing all the operations of the mind. "I did not know," said he,* forty years afterwards, "the first words of moral philosophy, but I had need of 200 pounds to furnish my house. The success was prodigious." Smith is pleased to exaggerate his ignorance. He had passed five years at Edinburgh, and had enjoyed opportunities of hearing Dugald Stewart and Thomas Brown in their favorite science.

The first course commenced in November, in 1804, the second was delivered in the spring of 1805, and the third the following year. Conversation, during the winter of 1804–1805, turned scarcely on anything else but the young Roscius and his lectures. He had from 600 to 800 auditors, (*Quarterly Review*, No. xcvii.) Yet, if we are to believe the celebrated Review founded by Sydney Smith, it would be impossible to conceive an assembly less prepared to comprehend the mysteries of the understanding than a metropolitan audience at that epoch.†

* Letter addressed to Dr. Whewell in 1843. *Quarterly Review*, No. xcvii.

† *Edinburgh Review*, No. xci. The lectures of Sydney Smith have been published in 1849, at London, under the title: ***Elementary Sketches of Moral Philosophy, delivered at the Royal Institution, in the years* 1804, 1805, *and* 1806.**

XIII.—Brande, the successor of Davy, at the Royal Institution.

It has been seen that Davy gave his last lecture at the Royal Institution April 9, 1812, but did not resign the chair till a year afterwards. In the interval, Mr. W. T. Brande (born at London January 11, 1788) was invited by the directors to prepare a course of trial lectures, which was delivered in 1813, and was immediately followed by his nomination to the vacant chair. The same year Copley's medal was awarded to him by the Royal Society for his communications on the alcohol contained in fermented liquors, and other memoirs published in the *Philosophical Transactions.* In 1816 he replaced Walloston as one of the secretaries of the Royal Society, and occupied that post, for which he had been designated by Wollaston himself, till 1826.

Mr. Brande has been successively superintendent of the chemical operations at the College of Pharmacists, in London, professor at the Royal Institution, and warden at the English Mint. He resigned his chair at the Institution March 16, 1852, and gave his last lecture April 3. The following are the terms in which he took leave of his auditors:

"I have aimed in this course to show the intimate relation which exists between abstract science and the useful arts, between the refinements of modern chemistry and the improved and extended condition of some of our principal manufactures; and having terminated that course, it remains for me to take leave of you. I can say conscientiously that it is with reluctance that I quit my chair, but the hoarseness to which I am subject has, for some time, so interfered with my lectures, and is so evidently aggravated by the exertion of speaking, that the measure has become, if not a necessity, at least an act of prudence.

"I have been officially attached to the Institution for a period of 40 years. During the greater part of that time, from 1815 to 1848, I gave also a series of lectures and demonstrations on theoretical and practical chemistry in the laboratory beneath us. They were designed for students of every kind, and took place three times a week, from October to May. They were the first lectures given in London in which the attempt was made to embrace so extensive a view of chemistry and its applications, comprising technical, mineralogical, geological and medical chemistry; and I recur to them with much satisfaction, because I can legitimately claim for them the merit of having sustained the plan of this Institution and added to its usefulness; of having aided in diffusing the knowledge and love of science, to-day so general; of having done this for students of every grade and of all classes; and of having thus fulfilled one of our principal objects.

"As regards the lectures which are given in this amphitheatre, I will not dissemble that I relinquish them with regret. The instruction here given in chemistry has to me been always a pleasure; and it has not been nor can it be granted to more than a very few to teach it with success, and to such an auditory, for so long a period. * * * Other thoughts still press upon me, when I look back upon the long years which I have passed within these walls. I rejoice that I leave the Institution more prosperous, in all respects, than at any former epoch; its scientific reputation better established, its foundation more solid, its halls more frequented, its usefulness better recognized; and I cannot but see in it a fruitful source of the popularity of science, and the extension of schools destined for scientific instruction, features which so eminently distinguish the present age, and which are especially manifest in this powerful metropolis. * * * When I regard the Royal Institution under a *personal* point of view, I reverence it as my *alma mater*, where, while yet a scholar, I listened to the pregnant eloquence of Davy, before I enjoyed his acquaintance and shared his friendship; where I was distinguished by the patronage of Sir Joseph Banks; where I was chosen by Wollaston to succeed himself as secretary of the Royal

Society; where I have been frequently brought into contact with the chiefs of science, of literature, and of art; where Faraday became my pupil, my colleague, and my friend."

Mr. Brande was named honorary professor, and the chair of chemistry was given, in 1863, to Mr. Edward Frankland.

XIV. — Mr. Faraday. — His outset in life. — His researches and lectures.

Mr. Faraday (Michael) was born in 1794, at Newington. His father, who was a farrier in narrow circumstances, early apprenticed him to a book-binder of London. At spare moments, the young Michael occupied himself with the construction of the instruments of physics; he even succeeded in making an electrical machine. It occurred one day to his master to show these objects to a customer of his, Mr. Dance; and the latter was so much pleased with them that he procured for this apprentice, at once book-binder and physicist, permission to attend the four last lectures of Davy at the Royal Institution, of which Mr. Dance himself was one of the earlier members. Faraday, seated in the gallery, heard with attention and took notes; so that he was able to write out the lectures and send them to Davy, with a brief and modest mention of himself and a request to be employed in the operations of the laboratory of the Institution. Davy was struck with the perspicuity and accuracy of the memoir, and, having satisfied himself of the talents and industry of the author, offered him, at the beginning of 1813, the place of assistant, which had become vacant at the Institution. Faraday promptly accepted it, and, at the close of the year, accompanied Davy to the continent in the capacity of confidential secretary. On his return to London, in 1815, he resumed his functions at the Royal Institution, of which he was named director in 1825, and two years afterwards became one of the professors in ordinary.

The scientific researches of Mr. Faraday date from 1820. They have been conducted, like those of Davy, in the laboratory of the Institution, at the cost of the establishment, and without any assistance on the part of the state. He has himself indicated their principal object in a few lines:

"I had early conceived the opinion, I may even say the conviction, that the different forms under which the forces of matter manifest themselves have a common origin; or, in other words, have so direct a relation towards and dependence upon one another, that they are in some sort convertible among themselves and possess equivalents of power in their action."

His efforts have, therefore, been directed towards the reciprocal relations of heat, light, magnetism, and electricity; and he has succeeded in demonstrating that, to a certain point, the imponderable bodies, as they were heretofore called, are so many different manifestations of one and the same force. To speak here only of light, it may be mentioned that, after several abortive trials which failed to shake a conviction founded on philosophic considerations, he has succeeded in magnetizing and electrifying a ray of light, and in illuminating a magnetic line of force.

Nor are these the sole researches of Mr. Faraday, though to them his name has become more especially attached.

"The memoirs which he has published on other subjects,* and his public lectures, evince the extent of his inquiries. His rare merit as a professor is attested by the thousands of persons who flock every year to hear him. Posterity will applaud the ardor with which he has always embraced philosophic truths, without allowing any unworthy jealousy, as so often happens, to distort

* Mr. Faraday has succeeded in liquefying and even solidifying several gases regarded as permanent; among others, carbonic acid.

them in his eyes; nor will it fail to recognize in him a penetrating and exact reasoner, endowed with powers of imagination which communicate a degree of poetic vigor to his conceptions; a genius of extraordinary resources when experiments are to be devised for realizing his ideas, and singularly skilful in executing them; a scientific writer, clear, candid, and judicious, and often rising to eloquence, when the grandeur of the subject is capable of inspiring enthusiasm."—*Quarterly Review*, No. LXXIX.

Mr. Faraday received from the University of Oxford the degree of doctor of laws, in 1832, the same year when it was conferred on Dalton. He is one of the eight foreign associates of the French Academy of Sciences, as were also his distinguished predecessors, Davy, Young, Dalton, and Count Rumford, the founder of the establishment. He is regarded, in England, as the boast and stay, *decus et tutamen*, of the Royal Institution.

XV.—Mr. John Tyndall, Professor of Natural Philosophy since 1853.

The professor of natural philosophy at the Institution has, from 1853, been Mr. John Tyndall, doctor in philosophy of the University of Marburg. He was born at London, July 21, 1820, and pursued his studies at Marburg and Berlin; he is known as the author of numerous researches on the glaciers, and a work entitled *Heat Considered as a Mode of Movement*, a course of twelve lectures delivered at the Royal Institution, and which has been translated into French by the Abbé Moigno.

The theory set forth in these lectures considers heat as an effect of a movement of vibration communicated to the molecules of bodies. Count Rumford, who was the originator of this theory, "recognized a proof of it in the continual production of heat which takes place from movement. The boring of a bronze cannon, for instance, in a short time throws the water into ebullition, and this ebullition lasting as long as the movement which produced it, he found it difficult to conceive how, in such a case, a matter of any kind could be disengaged; for then it would necessarily be inexhaustible." (G. Cuvier, *Eloge Historique de Rumford.)* The molecular movement may be generated by friction, percussion, and compression, as well as by combustion. The mutual convertibility of heat and mechanical action has been demonstrated, and it is practicable to calculate the mechanical equivalent of heat, by which is to be understood the weight which, raised to the height of one metre, is the equivalent of the heat necessary to raise by one degree centigrade the temperature of a kilogram of water.*

XVI.—Chairs founded at the Royal Institution by Mr. John Fuller.—The Prize founded by Mrs. Acton.—The present Organization of the Institution.

In 1833 Mr. John Fuller founded, at the Royal Institution, two chairs, one of chemistry, the other of physiology; the former was given for life to Mr. Faraday; the incumbent of the latter is elected every third year. The two professors bear the name of *Fullerian Professor*, from the name of the founder. In 1838, Mrs. Acton invested the sum of £1,000, from the interest of which the Institution is to award, once in seven years, 100 guineas to the author of the best essay on the benevolence of the Almighty as manifested by scientific discoveries.

The Royal Institution of Great Britain is under the patronage of Queen Victoria. The charter granted it by George III, in 1800, was confirmed and extended, in 1810, by act of Parliament. It is an association of persons devoted

* The labor which consists in raising 425 kilograms to the height of a metre is capable of being produced by the quantity of heat requisite to raise by one degree the temperature of a kilogram of water: in other words, 425 *kilogrammetres* are equivalent to a *caloric*.

to science and desirous of promoting its progress; its principal objects being: (1) To stimulate to scientific and literary researches; (2) to teach the principles of inductive and experimental science; (3) to show the application of these principles to the different arts of life; (4) to afford opportunities for study. It comprises:

1. *Public lectures*, designed to supply what books or private instruction can rarely give, namely, experimental exhibitions, comprehensive designs or detailed descriptions of objects connected with science or art. They usually embrace a short course at Christmas,* and at least six courses, before and after Easter, the season extending from the middle of January to the middle of June. The usual subjects of these courses are some of the branches of the science of induction, such as mechanics, chemistry, heat, light, electricity, astronomy, geology, botany, and physiology. There are also, on occasion, courses upon subjects of general interest, such as literature, the fine arts, and music.†

2. *Weekly meetings* of the members of the Institution. These meetings take place every Friday evening during the season. They were established in 1826, the members having each the privilege of introducing two of his friends by ticket. The object of these reunions is to bring into contact men of letters and savants, and to furnish the opportunity of communicating, by discourses in the amphitheatre, either new views or new applications of known truths, or of demonstrating experimentally and of rendering familiar by description new results which have been recently recorded in the scientific memoirs of philosophic societies. Extracts from these discourses, prepared by the speakers, are printed in the Proceedings of the Royal Institution, a copy of which is sent to each member. The *Proceedings* began to appear in 1851; they constitute a sequel to the *Journals* of the Institution, which began to be published in 1802, but had undergone long interruptions.

3. *A laboratory*, for the cultivation and advancement of the chemical and electrical sciences, by means of original investigations and experiments. It is in this laboratory that the researches of Davy and of Faraday, as has been already said, were made, embracing a period of more than half a century.

4. *A library* of about 33,000 volumes,‡ comprising the best editions of the Greek and Latin writers and of the fathers of the Church; histories of the English counties; works of science and literature, of art and archeology; memoirs of the principal scientific academies and institutions of the world, with numerous historical and other treatises.

5. *A reading hall for study.* Here are to be found various series of memoirs and scientific publications, whether English, French, German, or Italian, and a great number of works relating to the natural, medical and mathematical sciences.

6. *A reading-room for journals*, furnished with the principal reviews, magazines, and journals of England, France, and Germany. The Institution subscribes to a circulating library with the view of giving the members an opportunity of seeing the newest works as soon as published.

7. *A museum*, containing a large selection of specimens of mineralogy and geology, collected by Davy, Hatchett, Wollaston, &c., and much of the original apparatus employed by Cavendish, Davy, Faraday, and others who have been

* This course has been long given by Mr. Faraday; it was specially designed for a juvenile audience and comprised six lectures, the subjects of which for the years 1857–'58 to 1860–'61 were: Static electricity; the properties of metals; the different forces of matter; the chemical theory of a candle.

† Of these courses those which have obtained most success in late years are: a course in nine lectures on the *History of Italy in the Middle Ages*, given in 1858 by M. Lacaita; and a course in nine lectures on the *Science of Language*, given in 1861 by M. Max Muller, and which has been printed and translated into French.

‡ This is the enumeration for 1863; it must be now much greater. A new catalogue of the library, accompanied by an index of authors and subjects, has been published by the keeper, Mr. Vincent. It includes a chronological list of pamphlets, dating from the reign of James I.

professors of the establishment; together with many other objects, given in great part by the members.

The collection of minerals dates from the year 1804. In a review of that period, (*Bibliothéque Britannique*, t. xxviii, 1805,) it is said, with reference to the Institution:

"This establishment has not ceased to extend and prosper. A considerable fund has been destined for a library, and, last year, a sum of £4,000 was procured by private subscription for the purpose of forming a mineralogical collection, to be attached to the establishment under certain conditions, with a laboratory exclusively intended for the regular assay of mines. The first idea of this useful undertaking is due to Messrs. Gieville, St. Aubyn, and Hume, distinguished amateurs of mineralogy and well known on the continent. They remark in their prospectus that, while on one hand the private working of mines is conducted in England with a combination of pecuniary, mechanical and chemical means of which no other country affords an equivalent, on the other hand there exists not a state in Europe where persons desirous of being instructed in this important branch of human knowledge find so little help in public institutions. This consideration leads them to propose to form by subscription: 1, a scientific collection of minerals on a large scale, comprising the most recent discoveries, and arranged in the order best adapted for offering complete sets and all the most interesting facts in mineralogy; 2, an office or bureau of assay, exclusively destined to the advancement of mineralogy and metallurgy. Each of these two establishments shall be conducted by a man of the first merit in his line and entirely devoted thereto, a condition necessary for the progress of science, for, although private and occasional researches may produce some interesting discoveries, the perseverance, which is always crowned by success, can only be expected from a savant exclusively devoted to this particular branch of study."

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Thus it would seem to have been in contemplation to annex to the Royal Institution something like a *school of mines;* but this project was abandoned for want of encouragement on the part of the government and the proprietors of mines.

XVII.—Continuation of the present organization—the financial situation.

The *members*,* after having been regularly presented, are balloted for, the first Monday in each month, and pay at their admission 10 guineas, (five guineas as a first annual payment, and five as a contribution to the fund of the library,) or 60 guineas in place of all payments. They are admitted to all the lectures given at the Institution, the libraries, the museum, the meetings on Friday, and have the right of voting at the monthly reunions. They can also introduce, by ticket, two friends to each of the weekly evening meetings, and their families have the privilege of attending the lectures at reduced prices. Further, by means of a supplementary subscription of 20 guineas once paid, or three guineas a year, each member can introduce personally or by written order a visitor to each public lecture.

The *annual subscribers* to the Institution pay five guineas, with an additional guinea to the library fund, at the time of their admission. They are admitted to all the public lectures given in the amphitheatre of the Institution, to the libraries and the journal-room, but they have not the privilege of being present

*The Royal Institution counted, in 1863, 17 honorary members, the Prince of Wales, the King of Wurtemberg, the Prince of Hesse, and 14 learned foreigners, among whom are M. Plateau, professor at the University of Ghent, and Ad. Quetelet, both elected in 1849. The Prince of Wales was elected, in 1863, vice-patron of the Institution, to replace the prince consort, Albert, who had exercised the same functions since 1843, and who had been assiduous in his attendance on the lectures and soirées of Friday.

at the evening reunions. The *widows* of *members*, and the *sons* and *daughters* of the same, if above the age of 21, are admitted for the season to all the courses and to the museum on the payment of one guinea; and to each special course on the payment of a half-guinea for each course. The *subscribers to the courses* pay two guineas for all the courses, extending from Christmas to midsummer, and a guinea for each special course. For the Christmas courses, youths below 16 years pay each a half-guinea.

The *members* of the Royal Institution meet 1st of May in general assembly to hear the annual report of the visitors on the condition of the establishment, to revise the accounts, and to elect a *president*, *treasurer*, *secretary*, fifteen *directors*, and as many *visitors*. The *vice-presidents*, six in number, are chosen by the president from among the directors. The treasurer may also be designated for this office.

The property of the institute—consisting of buildings valued at £15,000; furniture, £1,400; library, £6,500; laboratory and mechanical apparatus, £1,400; collection of minerals, £300—was estimated, December 31, 1862, at a sum of £24,600, (615,000 francs.) It possessed at the same period a capital of £29,341 (783,525 francs) vested in consols. This capital, which amounted, December 31, 1857, to but £25,166, had risen to £30,108 at the end of 1862. At this last date the total annual revenue of the Institution amounted to £5,532,

The expense of the public courses for 1862 amounted to £670, of which £453 were paid to professors other than those attached to the establishment. These latter received: The professor of natural philosophy, who lodges in the establishment, £300; the *Fullerian professor* of chemistry, who also lodges in the establishment, £96, besides £350 which he receives as director of the laboratory; the *Fullerian professor* of physiology, £96. We have not ascertained the amount of the salary paid the professor of chemistry, who is remunerated by the Institution.

MICHAEL FARADAY—HIS LIFE AND WORKS.

BY PROFESSOR A. DE LA RIVE.*

Science has just lost one of its most eminent and faithful representatives. Faraday died on Sunday, the 25th of August, 1867, at Hampton Court. He was born on the 24th of September, 1791, at Newington Butts, near London. In 1804, at the age of 13, he was apprenticed to a bookbinder, in whose workshop he remained eight years. So many books passed through his hands that he could not resist the temptation of opening and reading some of them. These readings, performed in the evenings after the work of the day was finished, gave him a taste for study, and in particular for that of the sciences. The *Encyclopædia Britannica* first of all introduced him to some notions of electricity; and it was afterwards, from the works of Mrs. Marcet, that he derived his first knowledge of chemistry. His labors received their permanent direction from this opening; their essential objects were electricity and chemistry.

"Do not fancy," he said to me in a letter† of the 2d of October, 1858, in which he gives me these details, "that I was a profound thinker or a precocious child; I had merely a good deal of life and imagination, and the tales of the Thousand and One Nights pleased me as much as the *Encyclopædia Britannica*. But what saved me was the importance I early attached to facts. In reading Mrs. Marcet's book on chemistry, I took care to prove every assertion by the little experiments which I made as far as my means permitted; and the enjoyment which I found in thus verifying the exactitude of the facts contributed essentially to give me a taste for chemical knowledge. You may therefore easily imagine the pleasure I experienced when I subsequently made the personal acquaintance of Mrs. Marcet, and how delighted I was when my thoughts went backward to contemplate in her at once the past and the present. Whenever I presented her with a copy of my memoirs I took care to add that I sent them to her as a testimony of my gratitude to my first instructress."

"I have the same sentiments towards the memory of your own father," adds Faraday, "for he was, I may say, the first who encouraged and sustained me, first at Geneva, when I had the pleasure of seeing him there, and afterwards by the correspondence which I regularly maintained with him."

Faraday here alludes to a journey in which he accompanied Davy to Geneva in 1814, and in which, during a stay which he made with his illustrious master at my father's, the latter quickly discerned the merits of the young assistant, and formed relations with him which were interrupted only by death. At the time when he travelled with Davy, Faraday was his assistant at the Royal Institution in London; and I must say that he has more than once expressed to me, both by letter and *viva voce*, his thankfulness to the eminent chemist who had admitted him to one of his courses, and consented, after running through the notes of this course prepared by the young pupil, to take him for his assistant.

After the journey just referred to, Faraday, with the exception of rare and

* Translated from the *Bibliothèque Universelle*, October 25, 1867, *Arch. des Sci.*, pp. 131–176.

† This letter was addressed to me on the occasion of the death of Mrs. Marcet, and the notice which I was about to publish on this distinguished woman. (See *Bibl. Univ.*, nouvelle série, 1858, vol. iii.)

short absences, never again quitted the Royal Institution, where he had his laboratory and his residence. Married to a lady worthy of him, and who shared and understood all his impressions and all his sentiments, he passed a life equally peaceful and modest. He refused all the honorary distinctions which the government of his country wished to confer upon him; he contented himself with a moderate salary and with a pension of £300 sterling, which fully sufficed for his wants; and accepted nothing supplementary to this except the enjoyment, during the summer, in the latter years of his life, of a country house at Hampton Court, which the Queen of England graciously placed at his disposal.

Without children, a complete stranger to politics or to any kind of administration except that of the Royal Institution, which he directed as he would have directed his own house, having no interest but that of science, and no ambition but that of advancing it, Faraday was of all *savants* the one most completely and exclusively devoted to the investigation of scientific truth of which the present century offers us an example.

One may easily understand what must be produced under such circumstances by a life thus wholly consecrated to science, when to a strong and vigorous intellect is joined a most brilliant imagination. Every morning Faraday went into his laboratory as the man of business goes to his office, and then tried by experiment the truth of the ideas which he had conceived overnight, as ready to give them up if experiment said *no*, as to follow out the consequences with rigorous logic if experiment answered *yes*. His every-day labor experienced no interruption except the few hours which he devoted from time to time to the exposition in the theatre of the Royal Institution, before an audience equally numerous and select, of certain parts of physics and chemistry. Nothing can give a notion of the charm which he imparted to these improvised lectures, in which he knew how to combine animated and often eloquent language with a judgment and art in his experiments which added to the clearness and elegance of his exposition. He exerted an actual fascination upon his auditors; and when, after having initiated them into the mysteries of science, he terminated his lecture, as he was in the habit of doing, by rising into regions far above matter, space, and time, the emotion which he experienced did not fail to communicate itself to those who listened to him, and their enthusiasm had no longer any bounds.

Faraday was, in fact, thoroughly religious, and it would be a very imperfect sketch of his life which did not insist upon this peculiar feature which characterized him. His Christian convictions occupied a great place in the whole of his being; and he showed their power and sincerity by the conformity of his life to his principles. It was not in arguments derived from science that he sought the evidences of his faith; he found them in the revealed truths at which he saw that the human mind could not arrive by itself alone, even though they are in such great harmony with that which is taught by the study of nature and the marvels of creation. Faraday had long and justly perceived that scientific data, so movable and variable, cannot suffice to give to man a solid and impregnable basis for his religious convictions; but he at the same time showed by his example that the best answer which the man of science can give to those who assert that the progress of science is incompatible with these convictions, is to say to them, And yet I am a Christian.

The sincerity of his Christianity appeared in his actions as much as in his words. The simplicity of his life, the rectitude of his character, the active benevolence which he displayed in his relations with others, gained him general esteem and affection. Always ready to render services, he could quit his laboratory when his presence elsewhere was necessary to a friend or useful to humanity. We see him putting his knowledge under contribution both for inquiries upon questions of public health or industrial applications, and to give

practical advice to an artisan or examine the discovery of a *débutant* in the scientific career. Only, as I have already said, with these exceptions, he made it a rule not to allow himself to be turned aside from the labors to which he had consecrated his life by occupations of another kind, or by those pretended duties of society which waste time, abridge intellectual life, (already so short,) and very often leave nothing behind them but emptiness and regret. It was not that he could not be eminently sociable when necessary, or that he did not allow himself some relaxations when, fatigued with work, he needed some repose. But these were only accidental circumstances in his life, which was so exclusively devoted to his laboratory.

The scientific career of Faraday was equally fortunate and complete. Named as early as 1823 a correspondent of the Academy of Sciences of Paris, he was called in 1844 by this same academy to occupy one of its eight foreign associateships, after having been associated successively with all the learned bodies of Europe and America. He was by no means insensible to these scientific honors, which he accepted with genuine satisfaction, whilst he constantly refused every other kind of honorary distinction.

But it is time to commence the more important part of this notice, that which is to be devoted to the examination of the works of Faraday. Only I may, perhaps, be allowed, before speaking of the works themselves, to say a few words of the manner in which Faraday worked.

Is it true that the man of science who wishes to interrogate nature must set himself face to face with his apparatus, make them act to derive facts from them, and wait until these facts have appeared, in order to deduce their consequences, and all without any preconceived idea? Most certainly the philosopher who could advance such an opinion has never experimented, and in any case this method has never been that of discoverers; it was assuredly not the one adopted by Faraday.

There is a second method also which was not his, although it is truly worthy of attention, and often fertile of results. This consists in taking up known phenomena and studying them with great precision, carefully determining all the elements and numerical data, so as to deduce therefrom the laws which govern them, and often also to show the inexactitude of the laws to which they were supposed to be subjected. This method requires great previous study, great practical talent in the construction of apparatus, remarkable sagacity in the interpretation of the results furnished by experiment, and, lastly, much perseverance and patience. It is true that it leads with certainty to a result; and this is its good side; but the difficult conditions which it imposes are so many obstacles which prevent its being generally followed, except by the highest intellects.

A third method, very different from the last mentioned, is that which, quitting the beaten track, leads, as if by inspiration, to those great discoveries which open new horizons to science. This method in order to be fertile requires one condition—a condition, it is true, which is but rarely met with—namely, genius. Now this condition existed in Faraday. Endowed, as he himself perceived, with much imagination, he dared to advance where many others would have recoiled; his sagacity, joined to an exquisite scientific tact, by furnishing him with a presentiment of the possible, prevented him from wandering into the fantastic. Still always wishing for facts, and accepting theories with difficulty, he was nevertheless more or less directed by preconceived ideas, which, whether true or false, led him into new roads, where most frequently he found what he sought, sometimes, indeed, what he did not seek, but where he constantly met with some important discovery.

Such a method, if indeed it can be called one, although barren and even dangerous with mediocre minds, produced great things in Faraday's hands—thanks, as we have said, to his genius, but thanks, also, to that love of truth

which characterized him, and which preserved him from the temptation so often experienced by every discoverer, of seeing what he wishes to see and not seeing what he dreads.

The works which have issued from his brain, so well organized, are numerous and varied; they relate essentially, as we have already stated, to chemistry and electricity. Those on the latter subject are by far the most numerous and important; we shall, therefore, devote to them the greater part of this notice, after giving a summary exposition of the others.

I. In 1816, Davy received a specimen of native caustic lime from Tuscany. He gave it to Faraday for analysis, and found that the account given was so perfect that he had it printed, and accompanied it with some observations. This success, by giving Faraday confidence in his own strength, encouraged him to attempt other original researches. He published (in 1817 and 1818) an investigation of the passage of gases through narrow tubes, from which it appeared that the velocity of the flow of elastic fluids does not depend upon their density alone, but also upon their individual nature. Various other points of chemistry and physics, besides those which had electricity and magnetism for their object, attracted his attention from time to time throughout the whole of his scientific career. Now we have a note upon the combustion of the diamond; then an investigation of the sounds produced by the combustion of gases, or by the superposition of a strongly-heated iron rod upon a mass of copper at the ordinary temperature, (Trevelyan's experiment;) and then, again, researches upon the limit of vaporization, or upon the evaporation of mercury at low temperatures. We may notice two important memoirs—one upon the explanation of certain optical illusions produced by bodies in motion, the other describing some new acoustic figures proceeding from the vibrations of the stratum of air in contact with the surface of vibrating plates. His elegant discovery of *regelation* (that is to say, of the power possessed by two fragments of ice when brought together to become amalgamated by the fact of their simple contact at a temperature above 32° Fahrenheit) followed into its consequences as it has been by Tyndall, has had a much greater influence than perhaps he ever expected. In all these notices, even the least important of them, we find an original idea, a new and striking point of view, which enables us at once to recognize Faraday. And, in connection with this, how can we omit to mention his simple and clear explanation of table-turning, and the ingenious experiment by which he so clearly shows the muscular efforts made unconsciously by the persons who, by laying their hands upon the table, cause its movement?

Let us now dwell for a few moments upon some researches of longer duration, the publication of which preceded, and also in great part accompanied, his great works on electricity.

In 1820 Faraday described two new compounds of chlorine and carbon. One of them is solid, transparent, and colorless; it crystallizes in little prisms and in laminæ, and is obtained by exposing to the direct action of the sun bicarbonated hydrogen gas with a large proportion of chlorine. The other contains less chlorine; it is liquid and colorless, possesses great density, and is prepared by passing the former through an incandescent tube, from which chlorine is set free. The discovery of these two compounds filled up an important gap in the history of chemistry.

Subsequently, (in 1825,) by the compression of the gas obtained from coal, Faraday obtained a new compound, which, no less interesting than the preceding from a scientific point of view, had besides a great industrial importance. This was a bicarburet of hydrogen in a liquid state, which was found to be a mixture of several compounds endowed with various degrees of volatility, and which could be separated by distillation. Every one knows the advantage, in the production of colors, derived from this by the illustrious chemist Hofmann, when he extracted aniline from it.

The discovery of this bicarburet of hydrogen was only an incident in the researches which Faraday had undertaken in 1823, upon the condensation of gases into liquids. His mode of operation in this investigation consisted in placing in one extremity of a recurved tube, closed at both ends, the necessary ingredients for the production of the gas, and plunging the other extremity in a freezing mixture. The gas, evolved in a closed space, speedily condensed into a liquid state in the refrigerated extremity of the tube. In this way chlorine, sulphurous acid, sulphuretted hydrogen, carbonic acid, protoxide of nitrogen, cyanogen, ammonia, and hydrochloric acid were successively reduced to a liquid state. With the exception of chlorine, all these liquefied gases were colorless and perfectly transparent; and all of them had a refractive power superior to that of water. The attempts made to reduce the other gases, especially hydrogen, oxygen, and nitrogen to a liquid state were fruitless. Twenty years later (in 1844) Faraday resumed these experiments by directly condensing the gases by mechanical processes in very strong and hermetically sealed tubes, refrigerating them by means of the mixture of ether with solid carbonic acid produced by Thilorier's method. The condensation could be brought to fifty atmospheres, and the lowering of temperature to −166°F., or 110°C. below 0°. In this way Faraday succeeded in liquefying, besides the gases which I have already mentioned, olefiant gas, phosphuretted hydrogen, and arseniuretted hydrogen, as also fluosilicic acid; but he did not succeed in solidifying them. On the other hand, by applying his new process to the gases which he had previously liquefied, he brought them not only to a liquid state, but even to that of transparent and crystalline solids; hydrochloric gas alone of these latter would not become solid, whilst hydriodic and hydrobromic gas were successively liquefied and solidified.

It is easy to understand all the importance of an investigation the result of which was to modify completely the received ideas as to the constitution of the permanent gases by causing them to enter into the category of simple vapors; this was to introduce into molecular physics a new and important notion, the consequences of which have gradually unfolded themselves.

It is also to a question of molecular physics that we must refer the memoir on the relations of gold and the other metals to light, published by Faraday in 1857. Among other interesting facts that this memoir contains, we shall cite that of a leaf of beaten gold, which, when placed upon a plate of glass, becomes perfectly transparent and colorless when it is brought to a high temperature, and which, when seen by transmitted light, resumes its green color when it is subjected to strong pressure. A great number of experiments upon the pulverulent deposits of various metals obtained by electrical discharges transmitted through very fine wires, led to remarkable results as to the variations of color arising from change in the molecular state of the same body. We also find in this memoir a detailed investigation of the various colors presented by different solutions of gold, and especially of the fine ruby-red tinge obtained by the solution of a quantity of gold which, if agglomerated into a single mass, would not occupy the seven-hundred-thousandth part of the volume of water which it colors. It is not necessary to dwell upon the interest presented by researches having for their object the study of the influence, still so imperfectly known, of the molecular structure of bodies upon their relations to light, and especially upon their transparency.

Among the numerous works of Faraday relating to the applications of science to the arts, we shall confine ourselves to citing his researches upon the manufacture of steel, and of glass for optical purposes, these being the most important.

It was by the analysis of the Indian steel called *wootz* that he was led, in concert with Stodart, to compose an alloy which had all the properties of this, by combining aluminium with iron and carbon. In a letter addressed in 1820

to Professor De la Rive,* he relates all the attempts made by his collaborateur and himself during two years of persevering labor, to discover the most satisfactory alloys. He indicates, as one of the best, that of rhodium and steel, and, as presenting curious peculiarities, that of steel and silver; this last alloy does not become a true combination unless the silver only forms one five-hundredth part of it. Platinum, on the contrary, combines in all proportions with steel, but it does not furnish so good an alloy as rhodium and silver for the construction of cutting-instruments.

Although interesting in many respects, the results which Faraday obtained in his great investigation of the alloys of steel were not proportionate in their importance to the time and trouble which they cost him. We may say the same of the laborious researches upon the manufacture of glass for optical purposes, which he made a few years afterwards, (in 1829.) It was upon the initiative taken in 1824 by the Royal Society of London, which named a committee for the study of the improvement of glass with a view to its optical use, that Faraday was called upon to occupy himself with it. Whilst he pursued the chemical part of these investigations, Dollond worked up the glass, and Herschel subjected it to the test of experiment. At the end of long and difficult experiments, Faraday ascertained that the greatest difficulty in the way of the fabrication of a good flint glass (that is to say, a very refractive glass) was the presence of streaks and striæ proceeding from a want of homogeneity, due, in its turn, to differences of composition between the contiguous portions of the same glass. The employment of oxide of lead in the composition of flint glass was the cause of this defectiveness, which could not be avoided even by making use of the most efficacious means of rendering the mixture perfect while in a state of fusion. Among the combinations tried, that of borate of lead and silica furnished a glass endowed with optical properties still more strongly marked than those of flint glass, and at the same time presenting a very uniform structure. This glass, which, on account of its great density (double that of flint glass) has been named heavy glass, is found, unfortunately, to have a slight yellowish coloration, which renders it unfit for optical purposes; but the labor which Faraday devoted to its fabrication has not been lost; for, as we shall see hereafter, this same glass, in the hands of the talented experimenter, became the instrument of one of his most beautiful discoveries.

In the long and curious memoir which he published upon the fabrication of optical glass, Faraday gives a minute description of all the processes employed by him—of the construction of furnaces, selection of crucibles, means of heating, various artifices, such as the injection of platinum in powder into the fused glass to cause the disappearance of bubbles, &c. It is a genuine instruction in chemical manipulation, and, as it were, a complement to his treatise on this subject, which was published in 1827, and has since gone through three editions. Only those who are called upon to experiment in the domains of physics and chemistry can appreciate the immense service which this treatise has rendered to them, by teaching them a multitude of processes of detail so valuable for them to know, and of which a description was previously nowhere to be found, so that every one was obliged to undergo an apprenticeship to them on his own account. It was necessary that a *savant* who for so many years had been struggling with the difficulties of experimentation, and who had been able to surmount them in so ingenious a manner, should give himself the trouble to describe the means which he had employed, so that his experience might be of service to others. Faraday was this *savant*, and his object was completely attained.

Here, perhaps, before proceeding to another set of subjects, we ought to speak of certain of Faraday's theoretical ideas relating to general physics, and more especially to the nature of the forces, and their correlation to each other and to the essence of matter; but we prefer not to discuss the opinions emitted

* See *Bibl. Univ.*, (1820,) vol. xiv, p. 209.

by him upon these questions until after the exposition of his works on electricity and magnetism. We must, however, at once admit that his views on these matters are very contestable, and that, if they inspired him to make experimental researches of the highest interest, this is a proof that, in the hands of a man of genius, even a bad theory may be the origin of the most beautiful discoveries.

II. I pass now to the examination of those works of Faraday which relate to electricity and magnetism. It is not without embarrassment that I approach this examination; for these researches are so numerous that it would be necessary to extend this notice beyond all bounds in order to give only a simple analysis of them; and they are at the same time so varied that it is impossible to explain them in the chronological order of their publication without confusion being the result. Thus, for example, the researches on induction are interrupted by others on electro-chemical decompositions, to be afterwards resumed and completed. Each memoir certainly forms a complete whole; but one memoir is most frequently followed by another the subject of which is quite different. It seems as if the author, after having treated one question, found it necessary to recollect himself before resuming it, and to divert his mind from it, so to speak, by taking up some other kind of work.

It has, therefore, appeared to me that the best thing for me to do was to group all these various works under a few distinct heads, so as to be able to give their essence without requiring to enter into too many details. The first would include all the researches relating to electro-chemistry; the second those which have for their object induction, whether electro-dynamic or electro-static; and the third the phenomena relating to the action of magnetism and dynamic electricity upon light and upon natural bodies in general. It is true that there are some works which elude this classification, as they will not enter into any one of our three divisions. But these are less important works, and such as were produced as occasions offered; that is to say, they are the fruit of some particular circumstance which attracted Faraday's attention to some special point. Such is, for example, the memoir which has for its object the investigation of the electrical properties of the *Gymnotus*—and that devoted to the evolution of electricity by the friction exerted against solid bodies by the globules of water or other substances carried up by vapor—experiments undertaken in consequence of the invention of Armstrong's machine. Lastly, there are others which only contain the more or less indirect consequences of the fundamental discoveries, which will be explained in one of the three subdivisions under which we have grouped them. We shall not dwell upon any of these, thinking that we may give a more exact and complete idea of all the progress which Faraday caused the science of electricity and magnetism to make by confining ourselves to pointing out in some detail the most prominent parts of his researches upon these subjects.

Faraday commenced with chemistry in his scientific career; it is therefore not surprising that he approached electricity by the study of electro-chemistry. It was, moreover, towards electro-chemistry that his attention must have been first directed in that laboratory of the Royal Institution which had witnessed the magnificent discoveries of Davy in chemical decompositions effected by the pile, and especially in the production of the alkaline metals. In taking up this subject Faraday only followed the traditions left to him by his predecessor.

His researches upon the electrical conductibility of bodies constitute a first step in this path. The business was to ascertain whether, as was previously supposed, the presence of water is necessary to render solid bodies conductors, and whether solid non-metallic (and consequently compound) bodies can conduct electricity without being decomposed. Commencing with water, which is an insulator when solid and a good conductor in the liquid state, Faraday shows that a great number of compound substances are in the same case. Such are many oxides, some chlorides and iodides, and a multitude of salts, which do not conduct electricity in the solid state, but, without any intermixture of water,

become excellent conductors when liquefied by heat, and are not decomposed by electricity with separation of their elements in the same way as aqueous solutions. To the list of these compounds Faraday adds that of those substances, either simple, like sulphur and phosphorus, or compound, such as the periodides and perchlorides of tin, and many others, which continue isolators when fused as well as in the solid state. In this first investigation, notwithstanding a great number of experiments in which he employed the influence of heat and of electricity of high tension in the study of the conductive power of solid bodies, he did not succeed in determining very accurately the conditions of electrical conductibility; he only ascertained that, with one exception, which he justly regards as only apparent, there is not a solid body which, on becoming conductive by its passage to a liquid state, is not decomposed by the electrical current. We may add, so as not to return to the subject, that Faraday sometimes had doubts upon this point, and that he even thought that water could conduct electricity without being decomposed. Now experiment shows that in all cases, even those which appear most favorable to this opinion, electricity cannot be transmitted under any form through a compound liquid body without this body undergoing electro-chemical decomposition.

As to the causes of conductibility, they are still far from being known; when we see bodies, such as the gases, becoming conductors when greatly rarefied, whilst under the ordinary pressure they are perfect insulators, we are compelled to come to the conclusion that the impossibility that we find of explaining this difference, as well as so many others presented in this respect by solid and liquid bodies, is due to the fact that we have not yet a correct notion of the molecular constitution of bodies. Perhaps the recent theories of several physicists, particularly that of Clausius, who regards the particles of bodies as being in a constant state of movement, may succeed in elucidating this subject, which is still so mysterious. Faraday himself had fully foreseen this relation between electrical conductibility and the ideas which we may form as to the nature of matter. In a remarkable article published in 1844 he showed, upon an experimental basis, that in the theory according to which a body is regarded as consisting of atoms possessing weight separated from each other by larger or smaller intermolecular intervals, there are a multitude of facts, some of which can only be explained by assuming that the atoms are the conductors and the molecular space an insulator, and the others by supposing that the intermolecular space is the conductor and the atoms insulators—a contradiction which is inadmissible. He concluded from this that we must imagine matter to be continuous, or rather imagine the atoms to be simply centres of force, and consequently replace the atomistic by the dynamical theory. We shall often find traces of these ideas in the subsequent works of Faraday; for ourselves we cannot take this view. We are convinced that it is not by denying the existence of matter, properly so called, and admitting only that of forces, that we shall succeed in solving the difficulties under consideration and many others, but rather, following the example of Clausius and others, by modifying the ideas hitherto accepted as to the mode of constitution of bodies, and replacing them by others more in accordance with recent discoveries.

But we must return to electro-chemistry. I have already said that Faraday first occupied himself with chemical decompositions effected by the electrical current. He commences by effecting the decomposition of water and of solutions by means of a jet of ordinary electricity, rendered as continuous as possible by leaving a stratum of air interposed between the metallic points which convey and carry off the electricity from a machine, and a strip of moistened paper which this electricity traverses. He observes that the deposition of the elements, separated from the decomposed liquid, takes place against the surface of the air which is in contact with the paper. Then, investigating the decompositions effected by the pile, he examines the various explanations which have

been given of this phenomenon, and concludes that it is much rather a chemical phenomenon than a truly electrical one. In other words, it is a peculiar form of affinity which, under the influence of electricity, is exerted between the neighboring molecules, so that the decomposition is the easier in proportion as the affinity is stronger. He shows that the transfer of the elements can only take place between bodies the constituent parts of which have an affinity for each other: and if these elements separate in a free state against the surface of the metallic poles of the pile, this is because they cannot combine with the substance of these poles; for whenever this combination is possible, they are no longer set free. Water in some cases, air in others, as we have already seen, may serve as poles just as well as solid bodies. Faraday justly rejects the old idea of certain physicists who attributed electro-chemical decompositions to the ordinary electrical attractions and repulsions exerted upon the elements of a conductive liquid by the voltaic poles immersed in it. The metallic wires, or other conductors, which transmit electricity into a liquid, are merely, according to him, the roads by which the electric current passes into the liquid; therefore, to exclude any idea of electrical tension, which is more or less implied in the name *pole*, Faraday proposed to substitute for the denomination poles that of *electrodes*. He likewise applied the term *electrolysis* to the chemical decomposition effected by electricity, reserving that of *analysis* for the ordinary chemical decompositions in which electricity does not assist. Lastly, he gives the name of *electrolytes* to those compound bodies which are capable of being decomposed by the electric current.

After this preliminary and general study of the subject, Faraday enumerates the results which he obtained by submitting to electro-chemical decomposition a very great number of compounds, some of them simple acids or simple bases, others saline combinations. He dwells particularly on the secondary effects often manifested in these decompositions, especially in the case of aqueous solutions, in which decomposition of the water and of the substance dissolved takes place at the same time. But the essential point of his researches is the law at which he arrived as to the definite nature of electro-chemical decomposition. He demonstrates, relying solely upon experiment, that the quantity of chemical action exerted by an electrical current is proportionate to the quantity of electricity constituting this current; and, further, that the same quantity of electricity, or the same current, decomposes chemically equivalent quantities of all the compound bodies through which it is passed. Thus, if we place one after the other in the circuit of a voltaic pile, several pieces of apparatus arranged for the decomposition of water and for collecting the gaseous products of this decomposition, we find that in all, even when the degree of acidity of the water and the form and size of the electrodes are different in each, the same current traversing them for a given time produces the same quantity of gas, and consequently decomposes the same quantity of water. The quantity of water decomposed in a given time, appreciated by the quantity of gas evolved, is, therefore, the exact measure of the quantity of electricity which has produced this effect. Hence, like Faraday, we give the name of *voltameter* to the very simple apparatus which holds acidulated water destined to be decomposed by the current, and by means of which the volume of gases set free by this current in a given time may be exactly measured.

The second principle, that the same quantity of electricity decomposes chemically equivalent quantities of all compound bodies, was demonstrated by Faraday by placing several different electrolytes one after the other in the same circuit; as, for example, acidulated water in a voltameter, and protochloride of tin and chloride of lead in a state of fusion; and he obtains quantities of tin, lead, chlorine, hydrogen, and oxygen, which are chemically equivalent. Then, rising from the effect to the cause, he comes to the conclusion that there is a perfect equality between the electricity which decomposes a body and that which is

generated by the chemical action which produces the direct decomposition of an equal quantity of the same, or of a chemically equivalent quantity of some other body. He is thus led to pay attention to the theory of the pile, and to recognize that the power of this apparatus originates in chemical action, and not in the contact of two heterogeneous metals—a contact which is not necessary either to produce a spark or to cause a chemical decomposition.

He establishes, in the first place, that, either to effect a decomposition or to produce a spark, a plate of zinc immersed in acidulated water is sufficient without its being necessary to bring the zinc into contact with any other metal. He shows that in every pile the presence of an electrolyte (that is to say, a liquid susceptible of being decomposed) is indispensable for the evolution of electricity. Then, distinguishing in the electricity generated the intensity (or the tension) and the quantity, he studies the circumstances, depending either on the nature of the chemical action or the number of voltaic pairs associated, which exert an influence on these two characters of the current. In a word, he establishes such a correlation between that which occurs in the interior of a pile, and that which takes place in the electrolyte interposed between the poles of this pile, that it is impossible not to admit (with him) that electrolytic decomposition is nothing but a form of chemical affinity transferred from the pile into the electrolyte decomposed.

Wishing to obtain an idea of the quantity of electricity which is associated with the particles of which matter is composed, he endeavors to estimate that which is necessary for the decomposition of a grain of water, regarding it, as he is justified in doing, as equivalent to that produced by the direct chemical action (of the acidulated water upon the zinc) which decomposes this grain of water. He arrives at this incredible result, namely: that this quantity of electricity, appreciated by the heat evolved by it in traversing a fine platinum wire, is superior to that manifested in 800,000 discharges of a battery of Leyden jars, charged by thirty turns of a powerful plate-machine, and consequently equivalent to that constituting a violent flash of lightning.

The researches of which I have been speaking were made in 1833, 1834, and 1835. I had previously paid attention to the same questions, and had arrived by somewhat different methods at the same conclusion with Faraday, namely: that it is in chemical action that resides the origin of the evolution of electricity in the voltaic pile. Faraday frequently alludes to my investigations in a very kind manner; and subsequently (in 1840) he wrote me a letter in which he said that, being a thorough adherent of the chemical theory, he had just attacked the question directly, as I had already done, by demonstrating that contact alone, if not accompanied by chemical action, is not a source of electricity. The memoir in which he probes this question to the bottom is the last which he devoted to this department of electricity. In it, by means of a multitude of ingenious experiments, he demonstrates that the presence of an electrolyte (that is to say, of a liquid which is at once a compound and a conductor of electricity) is indispensable for the production of electricity in a voltaic couple; he varies his experiments in a thousand ways, sometimes by exhausting the number of chemical compounds employed as electrolytes, sometimes by the intervention of temperature or of other agents; and he concludes by showing by general considerations the improbability of the existence of a force of contact.

We may say that this last work, a precious supplement to the preceding ones, has rendered perfectly evident the truth of the chemical theory. This theory, foreseen by Wollaston and Fabroni, but opposed by most of the physicists of the early part of the present century, had found a powerful argument in its favor in the beautiful experiments of the elder Becquerel upon the electricity developed by chemical actions. It was then (from 1825 to 1835) that, profiting by these experiments, and seeking, on my own part, to make others of the same kind although in a slightly different direction, I published several memoirs to support

and render more precise the chemical theory of the voltaic pile. But I cannot but admit that we are indebted to Faraday for having based this theory upon irrefutable proofs, not only by the great number and variety of his researches, but especially by his beautiful discovery of the definite decomposing action of the electric current—a discovery which established between the external chemical action of the voltaic pile and the chemical action which takes place in the interior of this apparatus, a relation so intimate that it is impossible not to see in the latter the cause of the former.

III. In 1831 Faraday discovered electrical induction; it is the most important, although perhaps not the most brilliant of his discoveries. Ten years before (in 1821) he had observed a perfectly new phenomenon in the science of electro-dynamics—that science which issued complete, as we may say, from the brain of Ampère, after Œrsted's discovery. Struck by the experiments of the great French physicist upon the mutual attractions and repulsions of electrical currents and magnets, Faraday was led, by theoretical ideas which were rather disputable and not very comformable to the principles of mechanics, to assume that an electric current must turn round the pole of a magnet with a continuous movement, and reciprocally that the pole of a magnet must in like manner turn round an electric current. He verified this double result by experiment; and Ampère soon showed its accordance with his theory, adding to it other facts of the same nature. It is not the less true that the discovery of a continuous movement of rotation due to the combined action of a magnet and an electric current was quite unforeseen, and at the same time very important; for up to that time there was no example of any such action in physics. It was a first step in the course which was to lead to the finding of a relation between mechanical movement and the molecular forces.

Arago (in 1824) was the first who directly established this relation by his beautiful discovery of magnetism by rotation; for he showed that simple mechanical movement could render a body, in itself non-magnetic, capable of acting upon the magnet. Faraday advanced still further in 1831 by discovering that it was sufficient to bring towards, or remove from, a metallic wire forming a closed circuit another parallel wire traversed by an electric current, or simply a magnet, in order to develop in the former wire an electric current. He discovered induction—that phenomenon which so many others had sought in vain, although suspecting its existence, but which he alone had succeeded in producing.

Let us dwell for a moment upon his fundamental experiment. Two metal wires covered with silk are rolled together round a cylinder of glass or wood; the two wires are thus isolated, and have all their spires approximate and parallel. An electric current is passed into one of these wires; immediately a current is manifested in an opposite direction in the neighboring wire, the extremities of which are united by a galvanometer; but this current only lasts for a moment. The current passing through the first wire is interrupted; immediately another current is developed in the second wire, which is momentary, as in the former case, but directed in the same way as the producing current, instead of in the contrary direction. The momentariness of these two currents, and the fact of their alternately opposite directions, constitute the two important characters of this new mode of production of electricity.

Faraday did not stop at this. Starting from Ampère's idea that a magnet is only an assemblage of electric currents arranged round an axis in a manner very analogous to the circulation of an electric current through a metallic wire rolled into a coil, he tried the replacement, in his fundamental experiment, of the wire traversed by the current by a simple magnet. For this purpose he twisted a single wire instead of two into a coil round a glass or wooden tube; then he introduced a magnet into this tube, and ascertained that at this moment a momentary current is developed in the coil of wire, and that a second, equally

momentary, but in an opposite direction, is developed at the moment when the magnet is withdrawn. Here, therefore, was realized that production of electricity by magnetism which Faraday had long been seeking, convinced, as he was, that as electricity produces magnetism, magnetism in its turn must produce electricity.

Is it necessary to follow Faraday in the multiplied experiments by which he demonstrates that the electricity developed by induction possesses all the properties of voltaic electricity, and of the ordinary electricity produced by machines—that it heats fine metallic wires, gives shocks, and even produces the spark? To produce an electric spark by means of the action of a simple magnet, is one of those striking facts which give to the discovery leading to such a result a popularity, if I may venture so to express myself, which is reflected upon its author.

Faraday soon showed that terrestrial magnetism, like that of a magnet, can develop electric currents by induction in a metallic wire rolled into a coil or a circle, and actuated by a movement of oscillation in a plane perpendicular to that of the magnetic meridian. He found that it was not even necessary to employ metallic wires to ascertain the influence of the terrestrial magnetism upon the production of induced currents, but that it sufficed to set a metallic disk (of copper for example) in rotation in a plane perpendicular to the direction of the inclination-needle to find that it is traversed by electric currents passing from the centre to the circumference, or from the circumference to the centre, according to the direction of the rotation. Still more readily does the vicinity of a magnet to a similar disk set in rotation in any plane under the influence of this magnet develop in it induced currents, the presence of which, directly ascertained, explains in a perfectly satisfactory manner the phenomena of magnetism by rotation discovered by Arago.

These currents, although difficult to perceive, must nevertheless possess considerable power, since they can drag a rather heavy magnet by the action which they exert upon it. It is probable that this power is due less to their individual intensity than to their number, which appears to be very considerable. We may cite two examples which prove in a striking manner the energy which this mode of production of induced currents may acquire. The first is furnished by a curious experiment of Faraday's, in which, on causing a cubical mass of copper suspended by a thread between the poles of an unmagnetized electromagnet to turn upon itself, he saw this mass stop suddenly the moment he magnetized the electro-magnet, in consequence of the magnetic action exerted by the currents which induction had set up in the copper. We find the second example in the fact observed by Foucault, of the sudden stoppage which is likewise experienced by a thick disk of copper set in rotation between the poles of an electro-magnet the moment the latter is magnetized. This stoppage is such that it can only be surmounted by a considerable effort, and the disk itself becomes very strongly heated if the rotation be continued in spite of the resistance it meets with. In order that such a heating effect should be produced in a mass of such considerable size, and that we should experience an attractive action so strong on the part of the electro-magnet, the induced currents thus produced must be of very great power—a power which they owe essentially to the excessive rapidity of the movement generating them.

I shall not follow Faraday through all his works upon induction which accompanied his fundamental discovery. I shall only refer to the fact that in 1834 he discovered a new important fact, namely: the production of an induced current in the very wire that conducted the inductive current, and which takes place at first at the moment when the latter current begins to circulate, and then at that when it ceases passing. If this wire is rolled in a coil round a cylinder of soft iron, the effect produced acquires great intensity by the fact of the alternate magnetization and demagnetization of the iron which accompanies

the passage and interruption of the current in the wire. We all know the advantage that has been taken of this combination in the construction of very powerful apparatus. We also know how, from one improvement to another, we have come to find in induction, and consequently in the simple mechanical movement which gives birth to it, the most simple and economical principle for obtaining electricity, especially with regard to its application to therapeutics and illumination.

The discovery of electro-dynamical induction (that is to say, the production of a current by the influence of an exterior current) led Faraday to examine more closely than had previously been done into the phenomenon of statical induction—that is to say, the development at a distance of tension-electricity in an isolated conductor by the influence of an electrized body. He ascertained, what no one had previously suspected, that the nature of the body interposed between the source of electricity and the conductor submitted to the action of this source had a great influence upon the effect produced—that, of the various bodies, some facilitated the development of electricity at a distance, whilst others completely stopped it. He named the former *dielectrics;* and he proved that these dielectrics, which are essentially resins, sulphur, shellac, oils of turpentine and naphtha, &c., enjoy this property of transmitting electricity by influence in different degrees, whilst there is not in this respect any difference between the gases, which have the same dielectric power, whatever their nature or their density may be. On the other hand, none of the metals are dielectric; they are subject to the electrical influence, but do not transmit it.

From the investigation which we have just summarized, Faraday drew the conclusion that induction does not take place at a distance, but that it is effected by the intermediation of the particles interposed between the inductor and the inducted body. He assumed that these particles are polarized one after the other, which M. Matteucci afterwards demonstrated directly by experiment; that consequently the mode of propagation of electricity is the same in insulating as in conducting bodies; and that the various substances only differ from each other by the greater or less facility or rapidity with which this polarization, necessary for the transmission of electricity, takes place in them. Then, passing from this to the analysis of the different modes in which electrical discharges take place, some obscure, others luminous, some electrolytic, (that is to say, accompanied by the chemical decomposition of the conducting body,) others disruptive, (that is to say, effected by the mechanical disjunction of the particles of the interposed substance,) he applied himself more particularly to the study of the various forms displayed by the electric spark in more or less rarefied gases. I should never have done if I were to attempt to explain all the experiments which he made to elucidate these different points and to arrive at an idea of the actual nature of the electric current. The identity of the current, whatever may be its origin—that its production is due to polar forces which may exert a transverse action, as is the case in electro-dynamical phenomena—that these polar forces emanate from contiguous particles; such are the principles which Faraday endeavored to establish as the consequences of his experimental researches, at the same time that he rejected the idea of actions at a distance, referring all electrical manifestations to the presence of ponderable matter.

Whether or not we completely admit all Faraday's ideas, it is impossible not to acknowledge the immense advance which he caused the theories of electricity to make, either by demonstrating by experiment the falsity of certain conceptions generally accepted up to his time, or by opening up perfectly new points of view as to the actual nature of electrical phenomena. We have just had the proof of this in the consequences to which he was led by his investigations on statical induction. His discoveries in electro-dynamical induction have had still more important consequences, by introducing the notion of mechanical movement into the essence of electrical movement, and thus enabling Weber to com-

bine, in an equally ingenious and satisfactory manner, the mechanical phenomena of electro-dynamics, discovered by Ampère, with the electrical phenomena due to mechanical movement, discovered by Faraday.

Ampère and Faraday: two names which will always be united by the intimate relation of their works to the history of the science of electricity, in which they have opened such new and vast horizons; and yet minds as dissimilar in their mode of proceeding as similar in the power of their genius. Both eminently endowed with that faculty of divination which generates great discoveries, but one of them, Faraday, arriving at them by impression, by a kind of instinct which never deceived him, the other, Ampere, advancing with a more certain step, having as his instrument those calculations which he handled with such remarkable ability, and thus arriving at results which he hardly required experiment to confirm, so certain was he that this would not contradict him.

IV. I now pass to the last great series of Faraday's works. I have said, and, I think, proved, that induction was the most important of his discoveries; I must now say that the action of magnetism and electricity upon light was the most brilliant. Often the attempt had been made to see whether magnetism and electricity exerted any direct influence upon light; but these attempts had always failed. Investigators had operated upon luminous rays travelling in the air or in liquids, and endeavored to act upon them, sometimes by strong magnets, sometimes by electric currents or by statical electricity; but these attempts had led to nothing, absolutely nothing. All these negative investigations have never been published, but they have nevertheless been made.

Guided by theoretical considerations upon the mutual correlation of the forces of nature, Faraday, after many fruitless attempts, succeeded in finding the connection which exists between light and the magnetic and electric forces. Instead of taking an ordinary ray, he operated with a polarized ray; instead of acting directly upon this ray by means of a magnet, he submits it to the influence of magnetism while it is traversing a glass prism in the direction of its length. This prism, terminated by two square and parallel bases, the surfaces of which are well polished, and which are those by which the polarized ray penetrates and issues from the prism, is placed between the poles of an electro-magnet in such a manner that its length and, consequently, the direction of the transmitted ray are parallel to the line joining the magnetic poles. Lastly, the polarized ray on issuing from the glass prism only reaches the eye after passing through a Nicol's prism, which serves as an analyzer. It is also by traversing a Nicol's prism before penetrating into the glass prism that the ray of light is polarized; but this may be effected in any other manner.

It is well known that by turning the analyzing prism to a certain angle the polarized ray is extinguished in such a manner that the brilliant spot is replaced by a black spot. If, after this operation has been effected, a strong electric current is passed through the wire surrounding the electro-magnet, the black spot disappears and the bright one again makes its appearance. Then by turning the analyzing prism a little further in the same direction, the luminous ray is again extinguished; but this extinction ceases as soon as the magnetic action is suppressed by the interruption of the current which magnetized the electro-magnet. The action of magnetism, therefore, consists simply in causing the plane of polarization to turn by a certain angle, and to give artificially to the glass, while it is under the magnetic influence, a property which certain substances, such as quartz and essence of turpentine, possess naturally.

Any transparent substance, except gases, may serve, although in different degrees, as the *medium* for magnetism to act upon the polarized ray. But that by means of which this influence is best manifested is the yellowish heavy glass (borosilicate of lead) which Faraday obtained in his experimental researches upon the fabrication of glass for optical purposes. He happened to have at hand several specimens of this glass; and it was by using one of these for per-

covery to which I have just alluded is that as the magnet acts by attraction upon magnetic bodies, it acts also by repulsion upon all other bodies in nature. From this it results that whilst a rod of iron, or of some other magnetic substance, suspended between the poles of an electro-magnet, places itself *axially*, (that is to say, parallel to the line which joins the poles,) a prism of heavy glass (the same, for example, which served for the experiments on light) places itself equatorially, (that is to say, transversely to this line.) A rod of bismuth is in the same case; and this metal and heavy glass are the substances on which this repulsive action of the magnet is most distinctly exerted; but all bodies in nature which are not magnetic (and these are by far the most numerous) present the same property, although in various degrees. In this way Faraday comes to class all bodies under two heads: those which are magnetic or *paramagnetic*, as he calls them, such as iron, nickel, &c.; and those which are *diamagnetic*, such as bismuth, antimony, heavy glass, &c. The character of the former is to be attracted by the magnet, that of the latter to be repelled by it. It is true that this repulsion, to become sensible, requires an enormous magnetic power even in the case of bodies of which the diamagnetism is most strongly marked, whilst a very weak magnet is sufficient to betray its action upon the magnetic bodies, such as iron, steel, nickel, &c.

It therefore required very powerful means, such as Faraday employed, for the discovery of diamagnetism. Nevertheless a distinguished amateur in science, M. Lebaillif of Paris, had shown, as early as 1828, that a fragment of bismuth or antimony very evidently repels a delicately suspended magnetized needle when brought as near as possible to one of the poles of the needle, but without touching it. Mr. Faraday was ignorant of this circumstance when he published his first work on diamagnetism. I immediately informed him of it, at the same time indicating the journal in which I had published M. Lebaillif's experiment, which I had witnessed at the time. He accepted my reclamation in the most amicable manner, and at once, with his usual good faith, recognized the priority of M. Lebaillif with regard to bismuth and antimony.

In the numerous researches which Faraday devoted (from 1845 to 1855) to diamagnetism and at the same time to magnetism, there are some important points which I must indicate. He discovered the remarkable influence exerted upon this kind of properties by the molecular constitution of bodies, and especially by crystallization. He showed, for example, that a crystallized lamina of bismuth or antimony can place itself axially between the poles of an electro-magnet like a magnetic body, as well as equatorially, and that the position which it takes depends on the manner in which it is suspended relatively to the direction of its cleavage. He endeavored to investigate the force which comes into play in facts of this order, which he names *magnetocrystalline* force; whilst Plücker, on his part, widened its field by his beautiful and numerous researches on the manners in which crystals place themselves between the poles of an electro-magnet; and Tyndall, the worthy successor of Faraday at the Royal Institution, by his ingenious experiments analyzed the phenomenon in its generality and succeeded in connecting it, in a perfectly satisfactory manner, with the laws which govern magnetism and diamagnetism. Subsequently Tyndall succeeded also in demonstrating, by a decisive experiment, that diamagnetism, like magnetism, is due to a polarity caused by the influence of the magnet in the diamagnetic body, but with this difference, that, instead of opposite poles, homonymous poles are developed by the poles of the magnet. Thus fell to the ground all the other more or less rash attempts at explanation which had been given of diamagnetism.

Another point which deserves attention is the investigation which Faraday made of the magnetism and diamagnetism of gases. He arrived at this curious result, (observed likewise by Edmond Becquerel at the same time,) that of all gases oxygen alone is magnetic, and this in a very marked degree, while all the

forming the experiment just described that he discovered the magnetic rotation of the plane of polarization, a phenomenon which would probably have escaped him if he had made use of ordinary glass at first starting. Thus the long and painful labors to which he had formerly devoted himself without any great success, in order to discover a glass fitted for the fabrication of lenses, were not lost to science, since they facilitated his enriching it with one of his finest discoveries.

Let us now study the new phenomenon a little more closely, so as better to show all its importance. Some substances, we have said, naturally possess the property of causing the plane of polarization of a polarized ray traversing them to rotate through a larger or smaller angle; some cause it to turn to the right, and others to the left, of the observer. The discovery of Faraday was that the influence of magnetism or of electric currents develops this same property in nearly all transparent substances, but with this difference, that the direction of rotation of the plane of polarization depends only upon the position of the magnetic poles, or the direction of the currents with relation to the transparent substance. The law is, that if the north pole of the electro-magnet is placed on the same side as the observer who receives the ray into his eye, and consequently the south pole on the side by which the polarized ray enters into the substance, the rotation of the plane of polarization takes place, to the observer, from left to right. It takes place from right to left if the direction of the current, and consequently that of the magnetization, be changed. The action of the magnet may be replaced by that of a coil in the axis of which the transparent substance is placed. In this case, again, the rotation of the plane of polarization is very well observed when a rather strong current is transmitted through the wire of the coil; and the direction of the rotation is always the same as that of the current.

Thus, whilst in substances naturally endowed with circular polarization the rotation of the plane of polarization always takes place, according to the nature of the substance, either to the right or left of the observer, in Faraday's experiment the direction of this rotation only depends upon the direction of electric currents or the relative position of the magnetic poles, since it is completely independent of the position of the observer. These two kinds of action are therefore not identical, and we cannot say that by the influence of the magnet or of electricity we produce in all transparent bodies exactly the same property that certain substances naturally possess. Faraday well shows this difference by an experiment which consists in producing, by an ingenious artifice, the internal reflection of the polarized ray upon the extreme surfaces of the prism; this may be done once or several times before the ray is allowed to escape, and doubles, triples, or quadruples the angle of rotation of the plane of polarization, according as the ray is reflected once, twice, or three times. But when, instead of the magnetic, we have to do with the natural rotary polarization, the result is quite different, the return of the reflected ray neutralizing the effect which the direct ray had undergone while travelling in an opposite direction. In this case the angle of rotation of the plane of polarization reflected twice, and which consequently has three times traversed the transparent substance, is no greater than that of a ray which has only traversed it once.

The general phenomenon so unexpectedly discovered by Faraday has hitherto remained unexplained, notwithstanding many investigations, and especially the persevering and remarkable researches of M. Verdet.

It has not even been possible to connect it with some other property of bodies, although each substance has its specific magnetic rotatory power. Faraday, however, drew from it a general consequence which led him to another discovery, namely: that magnetism acts upon all bodies, since all transparent bodies may be modified under its influence sufficiently to acquire, in different degrees indeed, a power which they do not possess of themselves. The dis-

other gases are diamagnetic. Considering the great part taken by oxygen in the composition of our atmosphere, he attempted to explain, by the magnetic properties of this gas combined with variations of temperature, the phenomenon of the diurnal variations of the magnetic needle which he traced over all parts of the surface of the globe. It is impossible for us not to regret a little the considerable time which he devoted to this investigation, especially as it appears to us very probable that it is not in the action of the atmosphere, but much rather in that of the earth itself, or perhaps even in that of the sun, that we must seek the cause of all the phenomena presented by the magnetic needle.

Lastly, a third point remains to be noticed, namely, that which relates to the investigation of the magnetic field and of what Faraday denominates the lines of magnetic force. According to him, as we have already had occasion to remark, there is no such thing as action at a distance; consequently the magnetic field (that is to say, the space included between two approximated magnetic poles, such as those of a horseshoe magnet) is a medium from which, in every one of its points, forces emanate, the distribution and direction of which are indicated by the very regular arrangement effected by fine iron-filings placed in this space. The lines which he calls lines of magnetic force thus become visible and even tangible. But they exist none the less even when we cannot see them, and it is the displacements or modifications which they experience by the presence of a ponderable body in the medium in which they occur that give rise to all the remarkable effects of which the magnetic field is the scene. Such is, in a few words, Faraday's view upon this particular question.

We pass in silence over a multitude of interesting details upon diamagnetic polarity, upon the distinction to be set up between magnetic and diamagnetic bodies, and upon the possible relation between gravity and electricity. In 1850 Faraday reverted to this question, which he had previously attempted, but without success. We see that it is with regret that he is obliged to relinquish the discovery of this relation, which he had twice sought after; but with his usual good faith he admits that, although convinced that it exists, he was unable to find any fact to establish it. If experiment, which he knew so well how to employ constantly, gave him a negative response, would not this be because his point of view was not correct? and did not his error arise from his forming too vague ideas as to the transformation of forces, not taking sufficiently into account that it is the work effected by the force, and not the force itself, that must be considered in questions of this kind?

V. We have passed in review the principal labors of Faraday; and it only remains for us, in order to complete this notice, to endeavor to form an idea of the special character of these labors, and of the influence which they have exerted on the progress of science.

The first character that strikes us is their number. What Faraday published in the form of memoirs, from 1820 to 1855, is incredible. And what would it have been if, side by side with the multitude of experiments which he has made known, we placed in a parallel series those which he never published? It is true that if he has left them buried in his journal, it is because they gave him negative results; but from how many fruitless essays and erroneous attempts he would have preserved scientific men if he had not been so discreet!

A second character is the exactitude of the results obtained: I do not think that Faraday has once been caught in a mistake; so precise and conscientious was his mode of experimenting and observing. It must be admitted that in him the hand marvellously seconded the head; he was of remarkable dexterity, and possessed a practical talent, rare and precious in men of science, which enabled him, when necessary, to construct and modify his apparatus for himself, with the view of attaining with more certainty the desired result.

A third character, of quite a different kind and of much greater value, is the originality of the works of Faraday. A disciple of Davy, he undoubtedly

shows traces of the school from which he came, especially in the choice of the subjects of which he treats; but he does not blindly follow either the method or the steps of his master, and, soon quitting the beaten track, he strikes out a path for himself. What is this path? I shall be asked. This is not easy to say; but I will nevertheless attempt it.

At the commencement of the present century, thanks to the important works of which it had been the subject, the science of physics had acquired a character of precision and clearness which seemed almost to make of it a mathematical science. The fine treatise, in four volumes, on Experimental and Mathematical Physics, published in 1816 by M. Biot, gives the most correct and complete idea of the point at which this science had arrived. To the confusion which still reigned in the middle of the eighteenth century between the various departments of the science, to the ignorance which then still prevailed upon a great number of these departments, succeeded a clear and substantial analysis of all the phenomena, brought under simple and rigorous laws. Heat, light, electricity, and magnetism were regarded in it as so many distinct agents, having their special properties and obeying their own laws. Calculation was admirably fitted to these clear and precise conceptions; hence we find it greatly used, as witness the very title of M. Biot's treatise.

The great discovery of Œrsted, (in 1820,) upon the relations existing between electricity and magnetism, began to diminish confidence in this mode of considering the phenomena, a confidence which was already a good deal shaken by the researches of Fresnel and Arago upon light. The breach once opened, the fortress was soon entered; and among the most intrepid assailants Faraday figures in the front rank. By his researches on the condensation of gases, he shows that there is nothing absolute in the laws of Mariotte and Gay-Lussac and in the distinction so generally accepted between vapors and permanent gases. By his investigations upon voltaic electricity, he establishes between chemical affinity and the production of electricity a relation so intimate that it seems as if the one was only a form of the other. By his discovery of induction, he brings in mechanical movement as an important element in the production of electrical phenomena. By his experiments on the influence of the magnet and of electricity on polarized light, and by those which were the consequence of it, he opens to science a new path which no one had foreseen. He succeeds thus in establishing between the natural agents which we name light, heat, electricity, magnetism, chemical affinity, and molecular attraction such intimate relations, such a connection, that it is impossible not to think that we shall one day succeed in demonstrating that they are only different forms of the same agent. No doubt he is not the only one that has followed this path. Many others have brought in their contingent to this work of demolition and reconstruction; but he was one of the first, most active, and most persevering. Therefore his works, I have no doubt, will always be regarded as corner-stones in the new edifice which we are now endeavoring to construct.

I designedly say, *which we are endeavoring to construct;* for we must carefully avoid thinking that it is already constructed. Since the fine discovery of the mechanical equivalent of heat, it seems as if everything had been said and everything were easily explained by means simply of a ponderable matter, an imponderable æther, and a mechanical impulse. Vulgarizers of science, more anxious to produce an effect than to remain faithful to scientific truth, proclaim a molecular system of the world destined to form a pendant to the *Mécanique Céleste* of Laplace. According to them, nothing is more simple, nothing clearer; attraction itself, which has been the object of the study of so many superior minds, is merely the effect of an impulse easy to understand. A dangerous illusion! which, if it succeeded in propagating itself, would be as fatal to the true progress of science as opposed to its useful diffusion; for it is especially upon those who take to themselves the high mission of popularizing science

that it is imperiously incumbent to spread none but correct and well-founded ideas.

Let us not, however, exaggerate anything, or refuse to recognize in the too positive ideas which we have just combated that portion of truth which they may contain. With this purpose let us try, in conclusion, to lay down in few words the point at which, in our opinion, in the present state of science the important question of the unity of forces has arrived.

After having for a long time arrested the progress of science by abstract and general considerations upon the phenomena of nature, the philosophers finished by adopting, with Galileo, the experimental method, the only one that can lead with certainty to the discovery of the truth. A rigorous and profound analysis, placed at the service of this method, furnished certain and fundamental results. Reverting to a synthetic phase, many superior minds now seek by means of these tediously and painfully collected materials to reconstruct the edifice of which the raising was formerly attempted in vain. No doubt science has thus entered upon a fertile course, but only on condition of advancing with sure and consequently with slow steps. We speak of the unity of force, and of the transformation of forces one into the other; but do we know what are forces? do we know their nature? We have certainly proved transformations of movement, and shown that one work may change into another work, mechanical motion into heat, and heat into mechanical motion; these are, without doubt, the most important points gained by science, and enable us to get a glimpse of the existence of a single cause manifesting itself in various forms. But it is a long way from this to the discovery of this cause, this single force. Shall we some day arrive at it? It is possible and even probable; and in this case the name and the works of Faraday will always remain associated with one of the greatest problems which the human mind can entertain.

THE JUSSIEUS* AND THE NATURAL METHOD.

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Translated for the Smithsonian Institution by C. A. ALEXANDER.

Introduction. Few books of botany, or even natural history, have had more success than the small treatise of Magnol† (I say small, for it has less than a hundred pages,) entitled: *Prodromus Historiæ Generalis Plantarum in quo Familiæ Plantarum per tabulas disponuntur,* Monspelii, 1689. The fine preface of this little book—and it is only the preface which is fine—comprises but thirteen pages; and the name of Magnol, (such is the vitality inherent in ideas of a high order, when they are also the first, and touch upon some great problem,) can never be forgotten.

"After having examined," says Magnol, "the methods most in use, and found that of Morison insufficient and defective, that of Ray too difficult, ‡ I thought that I could perceive in plants an affinity, according to the degrees of which it might be possible to arrange them in different families, as it is customary to classify animals. This relation between animals and vegetables has given me occasion to reduce plants into certain families, (for thus I would call them by comparison with the families of men;) and as it seemed to me impossible to derive the character of these families from the fructification alone, I have chosen the parts of the plants wherein the principal characteristic marks are met with, such as the roots, stalks, flowers, and seeds; in a number of plants there is even a certain similitude, a certain affinity, which consists not in the parts considered separately, but in the whole. I doubt not that the characters of families may also be drawn from the first leaves of the germ at its exit from the grain. I have therefore followed the order observed by those parts of plants in which are to be found the principal and distinctive marks of families, and, without confining myself to a single part, have often considered several together."

There are many ideas in this page, and all of a striking character. Magnol perceives that *plants may be arranged in families* as we arrange animals; he seeks the *parts in which the principal characteristic marks occur;* he sees that the *characters of families may be derived from the first leaves of the germ, &c.* And yet how much uncertainty is still apparent—how much vagueness! Sometimes he considers such or such parts separately, the *roots,* the *flowers,* the *seeds;* sometimes he considers *several of them together;* sometimes he con-

*An account of several members of the distinguished scientific family of Jussieu will be found to be embraced in the present article. "When, in 1838," says M. Flourens, "I had pronounced before the academy the *Eloge* of Laurent de Jussieu, M. Adrien de Jussieu expressed to me an earnest wish that the study should be extended to all the members of his family, and that some details might be added to show their patriarchal habits and the ties of mutual regard which united them. He then confided to me certain private manuscripts which his premature death has devolved on me the duty of employing, and of which I have reproduced some extracts in this notice."

†Magnol was the first who introduced into the Method the word "family."

‡This method, *too difficult, though very learned* (*quamvis doctissimam,*) indicated at that early period the grand division of *monocotyledons* and *dicotyledons: hæc divisio* (that of dicotyledons and monocotyledons) *ad arbores etiam extendi potest: siquidem palma et congeneres hoc respectu eodem modo a reliquis arboribus differunt quo monocotyledones a reliquis herbis.* (*Joannis Raii, Methodus Plantarum Nova, etc.,* 1682.)

siders the *whole* of the plant. Hesitation is everywhere conspicuous, because the inquirer is destitute of a guiding principle—the principle established by Bernard de Jussieu and developed by his nephew Laurent—the principle, in a word, of the *subordination of characters.* "The natural method," said Linnæus, "has been the first and will be the last term of botany," (*methodus naturalis primus et ultimus finis botanices est et erit.)* To this end, in effect, have tended all persistent and comprehensive researches. When, in the middle of the sixteenth century, Gesner indicated the characters drawn from the fructification as the most essential,* he pointed out the right path. "It was Gesner," says M. Cuvier, "who discovered the art of distinguishing and classing plants by the organs of fructification, the art which has, in truth, created scientific botany;"† when, shortly after Gesner, Cæsalpinus founded the first *genera* on the *root* and *germ* ;‡ when, profiting by the labors of Gesner and Cæsalpinus, though without acknowledgment, Morison established his classification on the *seeds* ;§ when Magnol wrote the suggestive page just read ;‖ when Tournefort excluded from the constitution of genera every other character but that of *flowers* and *fruits* ;¶ when Linnæus published his Researches respecting *Natural Orders ;*** these vigorous intellects did but follow, by successive advances, the route opened by Gesner. The problem of the *natural method* was in the nature of an enigma, which they transmitted from one to another, and of which the two Jussieus, Bernard and Laurent, eventually found the solution.

The Jussieu family, natives of a small town in the mountains of the Lyonnais, which separate the basin of the Loire from that of the Saône, had then exercised, from sire to son, the function of notary for several centuries, when, about 1680, one of its members quitted Montrotier, near the hamlet which bears their name, in order to seek his fortunes elsewhere. This more enterprising member, whose name was Laurent, having taken his degrees in medicine, established himself

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"* Ex his (flore et fructu) enim potius quam foliis stirpium naturæ et cognationes apparent." (*Epist. ad Theod. Zuinggerum.*) "His notis (a fructu, semine et flore) staphisagriam et consolidam regalem vulgo dictum aconito congerem facile deprehendi." (*Ibid.*) "Melissa Constantinopolitana ad lamium vel urticam mortuam quodam modo videtur accedere, seminis tamen, unde ego cognationes stirpium indicare soleo, figura differt." (*Epist. ad Adolph. Occonem.*)

† *Bibliographie universelle*, article *Gesner.*

‡ "Partes sunt radix et germen : ex horum igitur differentiis prima genera constituenda sunt." (*De plantis*, 1, *cap.* 13.)

§ After claiming for his doctrines equal novelty and infallibility (*Plantarum Hist. Univ. Oxoniensis, seu herbarum distributio nova*, 1715,) pretensions on which the judgment of Magnol has already been seen, Morison proceeds to say: "Notas genericas et essentiales a seminibus eorumque similitudine petitas per tabulas cognationis et affinitatis disponentes stirpes exhibebimus. Differentias specificas a partibus ignobilioribus, scilicet radice, foliis et caulibus, odore, sapore, colore desumptas adscribemus."

‖ It was Pierre Magnol who replaced Tournefort at the Academy of Sciences as titular member. Magnol did not reside at Paris, but against such merit as his no rule is valid. I find in the proceedings of our ancient academy (February 6, 1709) this note of the secretary, Fontenelle; "I read to the company a letter from M. Pontchartrain to the Abbé Bignon, dated Versailles, February 5, in which it is anounced that, for the nomination of the 30th of January, the King has chosen M. de Magnol, though a non-resident, on account of his great reputation in botany. About the time when Morison, Magnol, Ray, published their general views, and thus opened for their successors the way to the study of the botanical affinities, Rivin, by a few pages replete with philosophic views, anticipated Linnæus in several points of the reform which was required in the nomenclature. (*Introductio Generalis in rem Herbarium*, 1690.) Morison's work, *Plantarum Unbelliferarum Distributio Nova*, bears the date of 1672; his *Plantarum Historia Universalis*, that of 1680; the work of Ray, *Methodus Plantarum Nova, &c.*, appeared in 1682; that of Magnol in 1689; that of Rivin, the title or which has been just cited, in 1690; and the *Elements de Botanique* of Tournefort in 1694. In every department, it is from the close of the seventeenth century that the first steps of the great philosiphic movement of the eighteenth century date their commencement.

¶ "Hæc, cum ita sint, genera plantarum statui non posse liquet, nisi flores simul et fructus adhibeantur." (*Isagoge in rem Herbariam*, p. 57, 1700.)

** *Fragmenta Methodi Naturalis vel Ordines Naturales*, 1738.

finally as a master of pharmacy at Lyon. He there married and became the father of sixteen children, three of whom, Antoine, Bernard, and Joseph, have, on different grounds, been remarkable among the most celebrated botanists of an epoch of unrivalled brilliancy as regards the cultivation of their science.

ANTOINE DE JUSSIEU.

Destined to the ecclesiastical profession and educated at the college of the Jesuits, Antoine had, from an early age, substituted for the rude sports of youth the observation of plants. This taste, already very decided in the child, became a passion for the young man. "He passed," says his biographer, Grand-Jean de Fouchy, "in searching for plants the whole time which his duties left at his disposal, and some of that, perhaps, which those duties might have properly claimed." From the age of fourteen years he explored, in his herborizations, the environs of Lyon, la Bresse, Bugey, Forez, &c., and even a part of Dauphiny. To find means of classifying the plants he collected, he addressed himself to a celebrated physician, M. Goiffon, who placed in his hands the *Éléments de Botanique* of Tournefort. This work gave a fixed direction to his ideas; and from that moment all traces of the ecclesiastic disappeared.

Having terminated his collegiate course, he ventured to avow to his father that he felt it impossible to direct his thoughts to any other subject than the study of nature, and, after some irritation and reproaches, this father, though chagrined at seeing his plans disconcerted, but having no grounds for doubting the sincerity of his son, yielded so far as to give him permission to pass from the seminary to the medical school of Montpellier. A place in a public vehicle was retained for the fugitive, but, notwithstanding the rigor of the cold, he made his journey on foot, still herborizing, and reserving his right of transport only for the purpose of sheltering the plants collected on the way. At Montpellier, neither his medical studies, nor even several years of practice as physician, in any degree estranged him from botany, for he had there had the advantage of hearing Magnol. Thenceforward his most earnest wish was to obtain access to the instructions of Tournefort, and as soon as circumstances permitted he repaired to Paris, with a view of attending the annual courses of that great botanist at the *Jardin Royal*. This was in 1708, and Tournefort, who had already sustained the accident which so prematurely removed him,* was no longer teaching. The surprise of Antoine may well be imagined when, not later than the following year, he found himself occupying, at the age of twenty-three, the chair from which he had hoped to receive instruction; for Isnard, who had been at first nominated for the succession, after a few lectures retired, and Antoine was then, at the instance of the admirers whom he had left at Montpellier, preferred to the vacant place.

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The volumes of our Academy contain several botanical memoirs of Antoine Jussieu on *Fungi*, on *coffee*, the *simarouba*, *contrayerva*, *torch-thistle*, *catechu*, &c.; and they contain also five on *fossil remains*, both of animals or vegetables, a subject of study then entirely new, and which, for that reason, would seem worthy of a passing notice. The first of these five memoirs has for its title: *An examination of the causes of the impressions of plants observed on certain stones of the environs of Saint Chaumont in the Lyonnais*, (*Memoires de l'Academie des Sciences*, 1718;) the second: *Physical researches on the petrifactions of different parts of foreign plants and animals which occur in France*, (*Ibid.*, 1721;) the third: *On the origin and formation of a species of convoluted stones, called horns of Ammon*, (*Ibid.*, 1722;) the fourth: *On the origin of*

*"As he was going to the Academy of Sciences he had his breast violently pressed by the axle of a cart which he could not avoid, and died December 20, 1708, aged only 53 years." (*Mémoire Historique et Littéraire sur le Collége Royal de France, par Abbé Goujet, article Tournefort.*)

stones called adders' eyes and toad-stones, (Ibid., 1723;) and the fifth: *Observations on some bones of a head of the hippopotamus, (Ibid.*, 1724.)

Of these memoirs the most important is the first; it is, so to speak, the author's memoir of *discovery*. And yet how far was the learned world at that date from any just conception respecting those phenomena of remote ages which every day become more imposing in proportion as they are better understood. If we listened to Antoine de Jussieu, the question would seem to relate only to certain national antiquities, which give to one people a title to glorify themselves above others on account of their possession. "There is no nation," he says, "which does not pride itself on the monuments of whatever nature which seem to indicate the antiquity of the country; when the still existing remains of human labor are not available for this purpose, recourse will be had to any other peculiarity which points to a remote origin. Even botany, since its recent and striking progress has attracted more general attention, has been laid under contribution as aliment for the sentiment in question. Thus MM. Lloyd and Woodward have arrogated honor to England from the discovery of stones on which have been observed the impression of different plants. M. Mill claims the same distinction for Saxony. and M. Leibnitz has enumerated all the places in Germany which may pretend to the possession of these ancient vestiges of nature. M. Scheuchzer, lastly, extols Switzerland for an unequalled affluence in these impressions of vegetable forms, whose types, he alleges, existed before the deluge." We see in this statement with how much fairness Antoine recognizes the title of other nations; but, proceeding to assert for France an equality of advantages in this respect, he says: "Of this I had an opportunity of satisfying myself when, passing through the province of the Lyonnais on my way to Spain, I traversed the environs of Saint Chaumont." The honor of France being thus assured, he enters upon the subject and recounts that up to the gate of Saint Chaumont and along the little river of Giés he *had the pleasure* of observing on most of the stones which he picked up, the impressions of an infinitude of fragments of plants, so different from all those which grow in the Lyonnais, the neighboring provinces, and even in the rest of France, "that it seemed to him as if he were botanizing in a new world."

This explorer of a *new world*, and relatively much more *new* than he supposed it, first remarks that in these stones the impressions of plants are found only on the surface of the laminations. He next remarks, that on each flake or lamina they are different and placed in different directions, and the number of these flakes, the facility of separating them, the great variety of plants distinguishable, causes him, as he ingeniously says, "to regard these stones as so many volumes of botany which, in each quarry, compose the most ancient library of the world, and all the more curious inasmuch as these plants either *exist no longer*, or, if they still exist, only in countries so remote that we should have no knowledge of them without the discovery of these impressions." I have italicized the words *exist no longer*, as being in effect not a little remarkable, and as presenting, though under a rather hesitating expression, a first indication of the grand idea of the Buffons and Cuviers on *lost species*.

Among the thousands of strange plants which have left their traces on our rocks, the practiced eye of Antoine quickly recognizes capillarias, ceterachs, polypodiums, adiantums, osmundas, filiculas, and species of ferns which resemble, he says, "those that R. P. Plumier and M. Sloane have discovered in the islands of America, and those which have been sent from the East and West Indies." He recognizes also leaves of palms and other foreign trees, peculiar stems, seeds, &c. But how does it happen that all these strange plants, these plants of India and America, occur in this country, in France, in the Lyonnais, at Saint Chaumont? Antoine is not willing to have recourse to the deluge; he is content with simpler means: "Without being obliged," says he, "to recur either to the inundation of the universal deluge, or to those earthquakes and violent

concussions which have produced great openings through which the waters of the sea have entered ;. without speaking of the fearful overthrow of vast mountains which, in their fall, have occupied a great space in the bed of the sea, and thrown its waters far inland, *there is no want of proof* that the greater part of outlands, which seem to have been inhabited from time immemorial, were *originally* covered with the water of the sea, which has since either insensibly or suddenly abandoned them." No; truly, *there is no want of proof* that the greater part of the land has been covered by the waters of the sea, and not only *originally*, as Antoine says, but repeatedly; for *originally* will not suffice; and in the present case it is evidently necessary that the earth, before being covered by the sea, should have been first dry land, since it had already produced *terrestrial plants;* there had been, therefore, two epochs, and there are two facts: the *irruption* of the seas and their *retreat*. "From the moment," says Antoine, "that it is apparent that different places have been covered with water, it is easily comprehended that impetuous floods, impelled from north to south, and again repelled from south to north, whether by the resistance of high mountains or by violent hurricanes, have swept with them the animals and vegetables of southern countries, and that in this reflux the waters having entered and remained in the recesses where certain mountainous formations have constituted bays or basins, have there retained these light bodies, some entire, others broken." Thus, *impetuous floods* driven to and fro, *violent hurricanes, arrangements of mountains*, constitute the mechanism which Antoine imagines for such grand effects, and which draws from Fontenelle the remark that "in such matters it is enough to obtain the faintest glimpse of a system." It was enough for the time. Limited explanations must precede comprehensive ones; and, in regard to the causes, so long hidden, of the displacement of seas, one could scarcely expect from a botanist who wrote in 1718, the bold and profound system which has been only granted in these latter days to the persistent efforts of the most intrepid of our geologists, Leopold von Buch.

I may dismiss the other memoirs more briefly. In the second our botanist examines a fossil seed, which he believes to be that of the *arbor tristis, (Nyctante de l'Inde,)* of which marvelling travellers had related that it blossoms at night, and that its flowers fall at daybreak, because they open in the evening and close in the morning; in the third he considers the *horns of Ammon*, which he takes for the shell of the nautilus; no wide mistake, since these fossils, or, as we now call them, *ammonites*, a species wholly lost, were, in fact, cephalopods mollusks, closely allied to the nautilus; in the fourth he treats of *adders' eyes and toad-stones*, which, notwithstanding their absurd names, he rightly recognizes for the teeth of certain fishes, and in one case, with rare precision, for the teeth of the *pogonias;* and in the fifth he discusses certain *fossil bones*, which he properly refers to the hippopotamus; thus, in the early years of the last century, presenting some curious attempts, to which their date at least gives an interest, in fields of inquiry which have most largely occupied the science of modern times. I find the same sagacity, and, if I may so term it, *precocious* curiosity in another memoir, which has remained unpublished, and which is entitled "*On the necessity of a new arrangement of plants in reference to the foreign ones recently discovered.*" The author, in the first place, earnestly deprecates any intention of interfering with the method of Tournefort. "At the proposal," he says, "of a new arrangement of plants, there is perhaps no one who will not suppose that some innovation is contemplated in the method invented by M. de Tournefort, and that it is on the ruins of the work of that illustrious academician that changes of importance are to be introduced, under pretext of rendering more easy the study of botany; but we are very far indeed from wishing to interfere with an arrangement of classes and genera so happily conceived, and which has united the suffrages of men the most expert in this science. The aim, on the contrary, is only to give to that method a new degree of perfection resulting from

the observations made by sundry botanists during the lapse of nearly fifty years in different foreign countries; observations which can only be rendered of advantage to botany by referring them to the place which they would naturally occupy, and which M. Tournefort would not have failed to assign them, had he lived till this day."

The modification, or, to use his own phrase, the *new perfection*, which Antoine proposes to introduce into the method of Tournefort, does not in effect intrench upon the spirit, the essence of that method. It proposes, as he explains, only to add certain new classes or sections in order conveniently to admit the plants recently discovered in foreign countries; but he has done more than he proposed; for a question of pure method, he substitutes another wholly different and new, which as yet had no name, and which we now call a question of *botanical geography*. He establishes these three points: first, that our continent has a multitude of plants which are peculiar to it and which are not found in the new, and that the new, in turn, has a multitude of others which are not found in the old; secondly, that the greater part of the plants which occur with us arrange themselves in classes into which but few foreign ones enter, and conversely; and thirdly, that in the two continents there are a certain number of plants which pertain to both, and arrange themselves under common classes. These three propositions are strictly correct; and to appreciate their merit, it is enough to remember that at the moment when Antoine wrote, the able dissertation of Buffon on the distinction between the animals of the two continents did not yet exist.*

Strictly speaking, Antoine never occupied himself with method. We see this in the care with which he deprecates an intention of interfering with that of Tournefort; still more clearly from his *Discours sur les progrès de la botanique,* and more than all from the *Introduction a la connaissance des plantes.* He says, in the *Discours,* with reference to Fagon, who had called Tournefort to the *Jardin Royal:* "For what advances is not botany indebted to him in the choice of the most excellent person who had yet appeared, since he was skilful enough to fix the principles of a science which till then had floated in uncertainty?" And in the *Introduction,* "the most perfect of methods being necessarily that of which the rules are the most simple and invariable, there is none more distinguished by these characters than that which teaches us to know plants by their flowers and their fruits." Now, the method which teaches us to know plants by their *flowers and fruits* is that of Tournefort; and the whole Introduction of Antoine de Jussieu is little more than a summary exposition of that method. Nevertheless, thanks to Vaillant,† he had already formed more just ideas respecting the flowers, particularly the *stamens,* which Tournefort only regarded as *excretory vessels.* "We understand," says Antoine, "by flowers that combination of parts called *stamens and pistils,* serving for their multiplication."

A passage in his *Discours* paints, in an artless manner, the pleasure which the *Jardin Royal* yields to those who frequent it in the pursuit of science: "How great the satisfaction of being able, within so limited a space, to see at once whatever, in both the Old and New World, is most curious in the domain of vegetable nature; to be able in an instant to compare the imperfect state of botany among the ancients with that which we witness to-day; to have facilities for recognizing on the spot so many plants which it has been necessary to seek beyond seas and upon mountain ranges; without trouble to reap the benefit of discoveries which have cost so much suffering and toil to explorers, and to have it in our power to discriminate at a glance, and in the same parterre, so much of what constitutes the separate riches of each nation."

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* Antoine died in 1758, and the volume of Buffon on the distinct animals of the two continents appeared in 1771.

† It is proper to recall that six years before the celebrated *Discours* of Vaillant, a memoir had been published by Claude Joseph Geoffroy, of the French Academy, on the *Structure and use of the principal parts of flowers,* in which the sexual organs of plants are demonstrated.

It was Antoine de Jussieu who, in 1720, consigned to the Chevalier Desclieux, midshipman, that famous coffee plant which, transported from our conservatories to Martinique, has produced all which have been since reared there. The plant deserved an historian: "Europe," says Antoine, "is indebted for the culture of this shrub to the care of the Dutch, who brought it from Moka to Batavia, and from Batavia to the garden of Amsterdam, whence an offset was conveyed to Marly, presented to the King, and then sent to Paris to the garden of his Majesty, where we have seen it yield in succession flowers and fruit."*

I proceed, lastly, to notice a memoir by Antoine of a wholly different kind from those which precede, and in which, by a fortunate and brief excursion beyond the domain of strict science, he retraces for us historically the origin of the collection of vellums belonging to the *Jardin des Plantes*. The memoir is entitled: "*A history of the facts which have occasioned and perfected the assemblage of paintings of plants and animals on sheets of vellum, preserved in the Bibliothèque du Roi.*"

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This inestimable collection, begun in 1650 by Gaston of Orleans, and continued by Louis XIV, Louis XV, and Louis XVI, was at the latter date composed of sixty-four volumes or portfolios. At this day it comprises nearly a hundred, and it should be added that its scope has been greatly extended. No longer confined to plants and a few birds, it embraces all the classes of the animal kingdom; to zoology it has added comparative anatomy and physiology; and to the two living kingdoms, the inorganic: geology, mineralogy, and crystallography.

It has been seen how active was the life of Antoine de Jussieu, and how varied were the subjects with which he was occupied. Unprovided with fortune, he had been obliged to devote nearly all his time to the practice of medicine, in which he attained great eminence. Had he been enabled to place his active intelligence and ardent curiosity wholly at the service of science, much might have been expected from him. But while the labors which I have recited suffice for the illustration of his name, his best title to acknowledgment will be always that of having introduced into botany his brother Bernard, who for forty years was the companion of his life. "They journeyed and studied together", says their nephew, M. Adrien de Jussieu, and the younger profited by the situation of his brother to give himself wholly to natural science. Both being unmarried, they lived together in fraternal union, which on the part of Bernard might have been characterized as truly filial. The disposition of which they thus set the example, remarkable in itself, seemed innate in this family; paternal protection on the part of the elder; tenderness, respect, and confidence on the part of the younger; community of principles, of sentiments, often of studies, almost always of goods; a union of interests and affection rarely paralleled, at least in modern times. In a like spirit Joseph, the youngest,† came at a later period to join his two brothers, for whom he preserved the same deference, the same devotion."

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* *Histoire du café*, (*Memoires de l'Acad. des Sciences*, 1713, page 292, edition 1716.) The following, from this memoir, is a new proof of what I have remarked elsewhere, touching the law imposed upon our Academy, from its origin, of asserting nothing except on the *direct observation* of nature: "As the authority of authors who have not seen the objects is not decisive in point of natural history, and our Academy can only establish its progress on a scrupulous examination of nature itself, on verified facts and exact experiments, we may regard as imperfect the descriptions of the coffee plant which have appeared heretofore, since we have been enabled to make one from the tree itself now in the royal garden."

† This brother was also a botanist of distinction, and accompanied, in that capacity, the scientific commission sent by the Academy to Peru to measure a degree of the meridian at the equator. "His curiosity," says M. Flourens, "held him captive for many years in those regions so rich and unexplored, where he often joined the labors of the engineer with those of the botanist. To him Europe owes several new plants, the *heliotrope*, *cierge du Perou*, &c., with many curious and then unknown species. Condorcet remarks that, by a singular chance, he was an academician for thirty-six years, without having ever appeared at the Academy."

BERNARD DE JUSSIEU.

§ 1.—*His youth.*

This first founder of the natural method, whose name is so well known, whose personal history so little, was born at Lyon, 17th August, 1699. His youth seems to have passed without indications denoting any special taste or aptitude, much less superiority. Having pursued his early duties at the jesuits' college in Lyon, and completed that of rhetoric, his brother Antoine invited him to Paris, in 1714, that he might there finish his course of philosophy.

To be left to meditate in tranquillity was then the whole ambition of the young philosopher. But Antoine having, in 1716, projected a visit to the southern provinces of France, and thence to Spain and Portugal, took Bernard with him as a companion. It was during this excursion, and especially during his exploration of the Lyonnais and Saint Chaumont, that Antoine made his valuable observations on natural history. "His young brother," as their nephew Laurent tells us, "was then acquainted with but few plants, and had no decided taste for botany; the plants which he met with were examined, however, with so much attention that he never forgot them; and, at a greatly advanced age, still perfectly recollected the places where he had gathered them."

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In 1722 Antoine procured him the appointment of sub-demonstrator to the chair of botany at the *Jardin Royal*, and unequal as the position might appear to his merit and subsequent reputation, he could never be prevailed upon to relinquish it; nor, with the exception of two short trips to England, did he again quit the environs of Paris.*

In the mean time he had become a licentiate in medicine, in 1724, and in 1726, at the instance of Antoine, was enrolled as doctor in the medical faculty of Paris.

"The functions of Bernard at the *Jardin Royal*," as Laurent informs us, "consisted in directing the cultivation of plants, and in conducting in the country the herborizations of pupils who attended the courses. He also superintended the gardeners, and would relinquish to none the gathering of seeds, &c. Nor can we omit to notice his unalterable patience in the study of plants which he sedulously watched under all the forms they assume at the different stages of their growth." Tournefort had published, in 1698, a "History of the Plants in the Environs of Paris," and this work being out of print, Bernard gave, in 1725, a new edition, enriched with notes. The first of August, of the same year, the Academy of Sciences admitted him to membership.

I have already said that the two brothers lived together, and were unmarried. In this intimate union Bernard was indefatigable in the use of means for seconding Antoine. He foresaw and prepared everything for his lectures. When the care of the sick necessitated the absence of Antoine, on Bernard devolved the reception of their common friends, and however retiring his nature, he discharged this duty in such a manner that the fraternal mansion became the centre of a cheerful, as well as learned, society, where everything new in botany and natural history was unaffectedly discussed.

§ 2.—*Correspondence of Bernard de Jussieu and Linnæus.*

From the mutual letters of Bernard de Jussieu and Linnæus† we are enabled to form an idea of the singular contrast which existed between the two, united,

* Laurent remembered having heard him relate that on one of those occasions he brought back with him from London, in his hat, a pot containing two plants of the cedar of Lebanon, which had not, as yet, been seen in France. One of these two cedars forms, at this day, a distinguished ornament of our *Jardin des Plantes.*

† *Epistolæ Caroli à Linné ad Bernardum de Jussieu ineditæ, et mutuæ Bernardi ad Linnæum: curante Adriano de Jussieu.* (*Ex actis Acad. Art. et. Scient. Americ.*, t. v., ser. nov. Cantabrigiæ, Nov. Ang., 1854.) Most of the *Lettres* of Bernard had been published by Smith, but translated into English. M. Adrien de Jussieu has given them in latin, the language in which they were written, and interspersed them with those of Linnæus.

as they were, by a passion for study, and the same study; the one all enthusiasm and unreserve, of an activity incapable of restraint; the other always self-collected and calm, of an inertia almost insuperable. "These two celebrated men," says Vicq d'Azyr, "of whom each was the only rival whom the other could fear, were asssociated in many herborizations. The impatience of M. Linnæus, who never asserted anything without warmth, opposed to the simplicity and composure of M. Bernard de Jussieu, who looked on every phase of nature with a regard of equal satisfaction, could not fail to present a very surprising contrast." *(Eloge de Linné.)* This contrast is manifest even in the numerical proportion of the letters. Of the twenty-eight of which the correspondence consists, one is from Antoine, nine from Bernard, and all the rest from Linnæus. From his irrepressible inclination to learn from every one, as well as to communicate information to others, Linnæus had the pen constantly in hand. "Assuredly," he says to the Abbé Duvernoy, "if I had ten hands they would scarcely suffice to answer all the letters I receive; and if you were to see me at this work you would think that I did nothing but write and wasted therein both money and time." "If I had as many hands," he writes to Jacquin, "as the famous Chinese idol, I would still not have enough for all the answers I have to give. It is certain that I alone write more letters every year than all the other professors of the university together." Accordingly, while we have several volumes of the correspondence of Linnæus, as regards Bernard there can be no question except of single and scanty letters. It had required all the heat of Linnæus to melt the ice of Bernard, but this communicated heat could not subsist. Of the last twelve letters of the collection there is but one from Bernard. Linnæus grew weary, at last, of so inert a correspondent, and directed his epistolary ardor to other quarters.

The correspondence commences in 1736, and terminates in 1763, thus embracing a period of twenty-seven years. It opens with a letter from Antoine de Jussieu to Linnæus, but evidently only an answer, for Antoine mentions therein the "Flora of Lapland" as a work Linnæus had promised to transmit, and "which is eagerly expected in Paris on account of the early departure of our academicians for those frozen regions." It was, in effect, at this time that, with a view to a more precise measurement of the figure of the earth, Bouguer, Godin, and La Condamine were proceeding to Peru, and Clairaut, Camus, Lemonnier. and Maupertius to Lapland.

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The second letter is from Linnæus to Bernard. He had learned that Antoine had devoted himself with great succes to the practice of medicine, and is unwilling to trespass upon time so usefully employed. He therefore addresses himself to Bernard, as being more at leisure, and consequently more disposed to write. (How little did he know of Bernard.) Linnæus sends him his "*Critica Botanica*," and solicits his opinion on it: "I send you," he says, "my *Critica*, a work written in a crude and uncouth style. I have been constrained to publish it almost without devoting to it a single moment, my whole time being occupied by my *Hortus Cliffortianus*, which I propose to publish towards the end of the year." Bernard replies: "I have received your two letters, and your *Critica Botanica*," nor is there a word more respecting a book, which, by reforming the entire nomenclature of botany, substituted Linnæus for all other terminologists, and naturally aroused the jealous susceptibilities of all scientific cotemporaries. The fourth letter of the collection is again from Linnæus, and in this he announces himself as about to depart for Paris, where he arrived soon after, (in 1738.)

Linnæus was then aged thirty-one, having been born in 1707, the same year with Buffon, and, for three years, had been travelling in quest, if I may say so, of scientific adventures, having left home with a few crowns in his pocket, a passion for knowledge, *and hope*. From Sweden he had gone into Holland, first to Amsterdam, then to Leyden, and finally to Hartecamp. His resources be-

coming exhausted, Hartecamp opened for him new ones; he there found in George Clifford, celebrated for his taste for natural history, a generous friend. It was in the cabinet, the garden, the library of Clifford, that he wrote the following admirable works: The *System Naturæ*, the *Fundamenta Botanica*, the *Bibliotheca Botanica*, the *Genera Plantarum*, the *Classes Plantarum*, &c., and that other book, by no means to be forgotten, the *Hortus Cliffortianus*, a touching testimonial of the gratitude of a man of genius towards one of worth. In 1736 Linnæus made a short excursion into England, and two years afterwards passed into France.

At the time of his arrival, Tournefort and Vaillant were no more, and the two Jussieus held the sceptre of botany. He presented himself to Antoine, with a letter from Van Royen, a learned professor of Leyden, who said of him: "The bearer is Charles Linnæus, whom I would cheerfully name the *prince of botany*, if I acknowledged one."

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The Jussieus received Linnæus as Van Royen had hoped they would; and during the month he remained at Paris he was constantly with them, especially with Bernard, who placed himself unreservedly at his disposal. In announcing his projected visit, in the fourth letter, Linnæus had given the most lively and ingenuous expression to his hopes: "Happy shall I be if you grant me your friendship; if I shall be allowed to see your plants and those of Tournefort; if, through you, I can make some progress in a study for which an ardent thirst consumes me. Hitherto I have received the kindness of all the botanists I have met with, and I trust that you will not be more difficult." These hopes were not disappointed. To form an idea of the cordial union then cemented between these two individuals, it is only necessary to pass from the letter, in which Linnæus announces his departure for Paris, to that which communicates his return to Stockholm—from the letter of hope to the letter of acknowledgment: "I live in the recollection of your kindnesses, of your house, your table so liberally offered to me, your days which were all at my disposal, your garden, your herbariums, to which I had unrestricted access. I returned in safety to my own country, and fixed my residence at Stockholm, at first unknown to almost every one; soon afterwards I entered upon the practice of medicine, and with success; I have been recently appointed physician in ordinary to the marine; lastly, I have taken a wife, a friend long and ardently coveted, and, if I may say so between ourselves, sufficiently rich, so that I am leading at present a contented and tranquil life."

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Proceeding with the correspondence, I pass by a letter of Linnæus which mentions nothing new but the foundation of the Royal Academy of Sciences of Stockholm, in 1739, and arrive at a letter of Bernard; this time, a real letter, for the former was but a note: "I discovered," he says to Linnæus, "during last summer the flowers and entire fructification of the *Pilularia*, and have published a memoir upon it in the acts of our Academy. This year I shall add a history of the *Lemma of Theophrastus*, a plant allied to the *Pilularia*, but differing from it sufficiently to form a distinct species."

In the memoir on the *Pilularia*,* I remark a passage which could scarcely

* Bernard can, in strictness, be scarcely regarded as a writer. At most, he has left in the volumes of our Academy but three very short memoirs on botany, one on the *Lemma*, another on the *Pilularia*, a third on the *plantain*, besides a zoological memoir, not of greater length, on the *polypes*. The following brief analysis of the three botanical memoirs is presented by Laurent: "The first memoir (1739) gives a description of the *Pilularia*, a plant before but little known. He shows therein the sexual organs, which had not then been discovered, and proves, by their analogy with those of the ferns, that it is of the same family. The stamens especially are described with care, as well as the form of their pollen, and the phenomena which they present in the water, seen with the microscope. He compares them with those he had observed in the pollen of other plants submitted to the same examination. *Placed on water*, he says, *they presently eject, by a small rent which takes place at a point of their capsule, a jet of liquid or oily matter, which remains in the water without mixing with it, and in small globules of extreme tenuity. These grains of pollen, swelling in the fluid like small vesicles, have an*

have been written at that time by any other than the destined founder of the natural method: "My object," he says, "is not to demonstrate in this place the preference of one method over another; I only propose in the present memoir to compose the history of a singular plant of the environs of Paris, and if I have joined with this history, by way of digression, some observations which might seem foreign to it, it is because I have thought them necessary for the perfecting of the method." "The character of a plant," he continues, "is what distinguishes it from all those which bear some relation to it; and this character, by the established laws of botany, should be formed from an examination of the parts which compose the flower. We call that an *incomplete character*, or with M. Linnæus an *artificial character*, in which are described only some parts of the plant, while silence is observed respecting other parts which, according to the method one follows, are assumed to be unessential; whereas we understand by the *natural character*, that in which all the parts of the flower are designated, and their *number*, their *figure*, and their *proportion* are considered."

This being premised, Bernard proceeds to inquire to what place in the botanical field the plant which he is studying should be assigned, following first the method of Tournefort, and then that of Linnæus, and he very correctly decides that the *generic characters* proposed by Linnæus are better than those of Tournefort. "This character," he says, (that, namely, derived from the method of Tournefort,) "is incomplete, for it does not express all that is necessary to be remarked in the flower of the *Pilularia*, and it is not possible, from such a character, to give to this plant a place which will suit it in the classes of several botanical methods. The mode in which M. Linnæus establishes the natural character of plants, in his book entitled *Genera Plantarum*, *does* afford this advantage; it is more exact, and appears to me *to deserve some preference*."* From those last words we feel that Bernard already has a glimpse of something preferable to the process of Linnæus;† and, in effect, when he shall have sufficiently matured his ideas, he will not stop, as he does here, with considering together and on the same footing all the circumstances—*number*, *situation*, *figure*, *proportion*; he will see that they have not all the same signification, the same constancy, the same weight, and he will found the *natural method* on the decisive principle of the *relative importance* of the characters.

Quitting the memoir, I return to the letters and find there, at nearly every step, proofs of the profound attention with which Bernard applied his mind, from this time, to the search for the *natural method*. Linnæus makes an

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almost spontaneous movement, or movement of attraction, and after the rent or expulsion of the liquid, they remain flaccid and at rest."

"In 1740, M. de Jussieu presented a memoir on the *Lemma*, a plant known to the ancients, but in which flowers had never been observed. He showed that the small bodies situated at the base, and similar, in some respects, to those of the *Pilularia*, contain stamens and pistils. He describes both with the same exactness, observes the same phenomena in the pollen of the stamens, and draws the same consequences, assigning the *Lemma* to the family of ferns, in proximity to the *Pilularia*."

"The memoir presented in 1742 on a species of *plantain* which has but one flower at the extremity of each stalk, is also very interesting. The author shows, in this plant, two characters before unknown: the one, drawn from the absence of the pistil in this apparent flower, which is male; the other, from the existence of several female flowers, hidden in the axillæ of the leaves, at the base of each stalk of male flowers."

"In order to omit nothing of the little written by Bernard, we cite, in the last place, his memoir of 1747, *on the effects of the Eau de Luce* (a mixture of volatile alkali and oil of yellow amber) *against the bite of vipers*. "Having made repeated proofs of it," says Laurent, and being well convinced of the efficacy of this substance, he always carried a flask of it with him in his herborizations."—(*Notes manuscrites sur Bernard.*)

* *Memoires de l'Academie des Sciences*, 1739.

† We feel it also from these other words: "There can be no embarrassment in giving to the *Pilularia* in the arrangement of plants, a place which will suit it, from its manner of vegetating. As, in the natural method, the *monocotyledons* should form the first general division of plants, we will place it there, and, if there is any class into which it can enter, it appears to me to be that of the ferns." (*Mem. de l'Acad. des Sc.*, 1739.)

inquiry respecting his projected publication of the *Plantes* of Plumier.* In reply Bernard says: "The *Plantes* have not yet appeared, and will not appear before I have succeeded in arranging them in an order conformable to the natural method, or at least approximating to that method." In the following letter he felicitates Linnæus on his nomination to the chair of botany at Upsal. "I have received this news," he says, "with great joy, for, devoted as you are to the study of plants, your new position will give you new means of ascertaining that natural method which is the hope and desire of all botanists." What we have been reading above was written by Bernard from 1739 to 1742, and it was not until nearly twenty years later, in 1759, that he ventured to make, in the garden of Trianon, the first experimental trial of his ideas.

The memoir on the *polypes* exhibits Bernard under another aspect; he reveals to us, in this remarkable study, that singular sagacity which seemed instinctively to guide him to the truth in everything.† Nothing had more interested the naturalists of the XVIII century, and nothing was better calculated to do so, than the experiments of Trembley on the *polype*, that animal which is reproduced from a slip like a plant, which may be turned inside out like the finger of a glove, and every portion of which when cut off becomes a separate and entire animal. The *polypes* of Trembley's experiments were those of fresh water; the *polypes* of Bernard are those of the sea, animals not less surprising than the former, having equally the property of reproduction from a slip, like plants; composite, multiple animals, of which several live united together by a common trunk, having a common sensibility, a common movement and even a common nutrition, for what is eaten by one nourishes and suffices for all.

These animals had long been taken for plants; they were called *marine plants;* it was even thought that the flower had been discovered, and the author of the *discovery*, Marsigli, had become famous. Peyssonnel was the first who, in the pretended flower of the *coral*, had the sagacity to recognize, in 1727, a real animal, the *coralline animal*, as he called it, *the polype of the coral*, as we say at present; a fact which then appeared so strange that Reaumur, charged with the duty of announcing it to the Academy, did not venture to name the author. "The esteem," said he at a later period, "which I felt for M. Peyssonnel made me avoid naming him as the author of an opinion which could not fail to appear incredible."

Bernard wrote to Linnæus: "I have made some excursions, and, last autumn, traversed the coasts of Normandy, where I discovered things of no little novelty, and you will wonder, some day, to see how much the animal kingdom is enriched." In his memoir he says: "The diversity of opinions on the nature of the *marine plants*, so far from satisfying a botanist, has seemed to me only the more capable of stimulating his curiosity, and I acknowledge that mine has been excited by the desire of making some researches on this subject." He repairs therefore to the sea-coast, repeats the observations of Peyssonnel, finds them at all points exact, and, at his return to Paris, hastens to announce this to the Academy. Thereupon the question was considered to be decided, and a whole class of beings

* Since Bernard's time, the museum has received several manuscripts of Plumier, and in a rather singular manner. "Plumier had left a large number of manuscripts, some of great value, but his monastic brethren, among whom there was neither botanist nor naturalist, held them in very little estimation. At the epoch of the revolution, when the convents were visited and the libraries of the monks carried off, some of these manuscripts were found which had served for fire-screens. M. Laurent de Jussieu had them carried to the *Jardin du Roi*, and deposited in the library. (Cuvier: *Lecons sur l'Histoire des Sciences Naturelles.*)

† In proof of this "singular sagacity," we are told that "Bernard de Jussieu's scholars used to bring him flowers which they had mutilated or compounded with others, for the purpose of testing his knowledge, and he always recognized them immediately. Some of them having made the same experiment on Linnæus, he said, 'God or your teacher (Jussieu) can alone answer your questions.'" Cuvier, in a biographical memoir on Richard, calls Bernard "the most modest and perhaps the most profound botanist of the eighteenth century, who, although he has scarcely published anything, is, nevertheless, the inspiring genius of modern botanists."—(*Encyc. Americana.*)—Tr.

passed from one kingdom of nature into another. Reaumur, in turn, regretting the wrong which he might possibly have done to Peyssonnel by his silence, gave utterance to these generous expressions: "The attention which M. Peyssonnel had brought to his observations ought to have convinced me sooner that these flowers, with which M. Marsigli had endowed the different productions just spoken of, were in reality minute animals."*

The tenor of all the letters written by Bernard to Linnæus, or by the latter to the former, is the communication and discussion of novelties like these. "These things," says Bernard ingenuously to Linnæus, "constitute your delight and mine: *Hoc res sunt tuæ, sunt meæ deliciæ.*" At one time it is Linnæus who consults Bernard on some difficulty with which he is occupied. What is the *Peloria*, that species of *metamorphosis* which transforms certain flowers, the flowers of the *Linaria*, for example, from *irregular* flowers, as they usually are, into *regular* ones? Must this be considered a monstrosity? "That," replies Bernard, "is what the seeds sown cannot fail to teach us." Nor was he mistaken; the *Peloria* is reproduced by the slip, and is not reproduced by the seeds. Every one now knows with how new a light the admirable theory of M. De Candolle on the *primal symmetry* of beings,† has elucidated this phenomenon, which, on examination, has been found much more general than was at first supposed:‡ the *Peloria* is the *primitive* and *regular* type of the *irregular* flowers. At another time, it is Bernard who announces to Linnæus some new miracle of science: *Sed quid moror? Ecce nova panduntur orbi litterario miracula.* It chances, however, in this instance to be a false miracle; the matter in question being the *animalcules* which Buffon thought he had discovered in the liquids of females, and which do not exist there.§

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For another trait of Linnæus, we may cite the friendly warmth with which he everywhere speaks of Bernard; going so far at one time as to say "that he loves him more than any one else, with the single exception of his wife."

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The true key, indeed, to everything in Linnæus, is to be found in the inexhaustible fund of his geniality and goodness of heart. Thus, how touchingly does he speak in his letters of his pupils; calling Kalm, *Kalmus noster;* Hasselquist, *his dearest disciple.* We cannot wonder at the affection which they in turn all vowed to him. They might be said to have constituted a body of apostles intent on carrying his doctrines everywhere, and bringing back to him new subjects of study; with this view, Kalm betook himself to North America, Forskal to Arabia, Hasselquist to Egypt, Toren to the Indies, Osbeck to China, Thunberg to Japan, Sparrman to the South seas, &c. Through his disciples the world, in some sort, pertained to him. On the other hand, if kindliness is the characteristic of Linnæus, modesty is the quality which attracts us in Bernard.‖ Of this Linnæus is especially sensible, and Bernard is the only botanist against whom the former has not launched some shaft of petulant impatience. Well, indeed, might he be considerate of that signal disinterestedness and silence which left him the secure possession of a supremacy which Bernard alone could have disputed with him.

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* Respecting the whole history of the *coral animal* see the analysis of the manuscripts of Peyssonnel, which I inserted in the *Journal des Savants* for 1838.

† See the Memoir of De Candolle, Smithsonian Report for 1859.

‡ Linnæus had at first observed it only in the *Linaria arvensis;* it has been observed since in several other plants of different species.

§ See, in the notes of the edition which I have given of Buffon's works, the causes of this error.

‖ Nothing, his nephew Laurent tells us, was more familiar to him than the answer: *je ne sais pas* (I do not know.) Jean Jacques, who had become an enthusiast in botany, sent to ask of him what method he should follow. "None," replied Bernard; "let him study plants in the order in which nature offers them to him. It is impossible that a man of such genius should occupy himself with botany and not teach us something."

The last letter of Linnæus bears the date of March 1, 1763. He had just been named one of the eight foreign associates of our Academy, and says: "Of all the academic titles I have received, none has flattered me so much as this, with which I alone, of all my countrymen, have as yet been invested." On Bernard's part the correspondence had stopped much sooner; his last letter bears the date of 1751; a subject of no little regret, for it was towards this period that he made, at Trianon, the first trial of his natural orders. He would, without doubt, have said something to Linnæus on the subject, and however brief his communication, it would now be of much interest.

§3.—*On Bernard de Jussieu's mode of observing in botany.*

It is my good fortune, due to the kindness of Dr. Tessereau,* to be now able to add to the memorials already considered *sixteen* letters of Bernard; a number which, after what has been said, would seem almost incredible. But the explanation is not difficult: between Bernard and a certain M. Artur, *a member of the higher council of Cayenne*, to whom the letters are addressed, there runs, throughout the correspondence, an incessant exchange of reciprocal solicitations. Artur constantly urges Bernard to procure an increase of his appointment, which seems to have been scanty, and Bernard, as ceaselessly, presses Artur to send him plants and other objects of natural history. In an early part of the correspondence Bernard, under date of December, 1736, writes as follows: "You know that the seeds of all the plants of the colony interest us; I hope that you will be good enough to collect them for us, as time and opportunity permit. Pray do not neglect to send us roots of the simarouba, as well as branches charged with leaves and dried between paper, and the ripe fruit of that shrub; skilful as you are in drawing, you might sketch for us the flower it bears; and you are highly competent to give its description, with that also of the pareira brava, the ipecacuanha, and other plants recommended by their virtues in medicine or use in the arts."

Apparently Bernard's estimate of Artur's competency must have undergone some modification, for in the fifth letter he takes the trouble to compose for his guidance a very brief and yet complete treatise of elementary botany, taking care, at the same time, to spare, as far as possible, the sensitiveness of his correspondent.

"Exactness, in the description of all the parts which constitute flowers, becomes," he says, "more and more necessary for the perfection of the method which arranges plants in classes, and distinguishes essentially each species; we should not adhere solely to the form of the petals, and the part which, in the flower, changes into fruit; it is necessary to particularize the figure of the calyx, its composition, the different figure of the petals, the part they occupy, their number, their division, the number of the stamens; whether they stand alone and distinct, or whether, united in several bodies or a single one, they spring from the sides of a calyx or a petal. The pistils are sometimes single and sometimes many in the same flower; and there are three parts to be considered in them, the lower, which is the ovary, the middle, which is the style, and the upper and last, which is the stigma."

Everything in this little treatise is worthy of remark, for, in indicating to M. Artur the mode of observing, Bernard, at the same time, indicates the scrupulous, attentive, and complete manner (and for the first time *complete* in botany) practiced by himself. I think it proper, therefore, to reproduce the whole letter:

"These parts are not always found in the order in which I mark them; in that case, great attention is to be paid in observing the fact; these parts, too, are often multiple—that is to say, there are several ovaries, several styles, and several stigmas; again, their figure, situation, porportion, vary, and all this requires details; finally, the ovary becomes the fruit, either naked or enveloped, simple and

* An eminent physician and author of a valuable treaties on *hygiene*.

containing but one seed, or composite and divided into different loculaments, and the seeds have their appropriate form.

"There are, besides these particulars, bodies which are met with in the flowers, either on the petals, or simply adherent to these petals, to the calices, to the base of the embryons of the ovaries, where they appear as tubercles, cornets, ornamental leaves, or narrow strips. As they serve to secrete, in the interior of the flowers, a juice or honeyed liquid, modern botanists have given them the name of *nectarium;* it is important to remark, in any flowers, whether this body exists, what part it occupies, and what is its conformation. You well know that in plants some are hermaphrodites; others bear only flowers with stamens, and are males; others, which are females, have only pistils; there are some which, on the same stalk, are furnished, at different places, with distinct male and female flowers; we see what it is proper to observe, and also what is wanting in the characters which have been established in the methods we possess respecting plants. If you have time to labor more at botany, you will do well to verify all that may suggest itself to you in reference to the principles I have above indicated; you will not only find in the occupation a source of pleasure, but will be enabled by your researches to correct, reform, and authenticate more particularly whatever information is attainable respecting the plants of the colony of Cayenne. In adapting your phraseology to the plants which you shall arrange according to species, do not make use of comparisons, but express, in few words, the specific mark which you perceive in a species, which serves to distinguish it from those you already know; if you know but one of the species, it is useless to bestow upon it other phrases than the name it bears or which you may assign it, for we should not distinguish a species which is unique; this would be to distinguish the known from the unknown, and the consequence is obvious. I write in haste, and may have failed to explain myself clearly; have the goodness to supply what is wanting, by omitting no circumstance of what you see in the plants you wish to describe; be on your guard respecting the varieties which cultivation or a difference of soil may present; these should be left to the amateurs of flowers and fruits. Adieu, my dear colleague."*

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§ 4.—*The catalogue of Trianon.*

The papers which contain this valuable memorial, the first foundation of the natural method, are inscribed with this title: *Order established by M. Bernard de Jussieu for the plants in the garden of Trianon, in* 1759; with a notification by Laurent, importing that "from this catalogue, written by his own hand, was copied that printed in the *Genera Plantarum.*"†

In this *catalogue of Trianon,* everything is reduced to a list of names; but these names are arranged in a determinate order, and that happily-conceived order has been found to contain the key of the natural method. Linnæus also had, before Bernard, given in his *Classes plantarum* (1738) a series of names, *fragments,* as he expresses it, *of the natural method—Fragmenta naturalis methodi.* How comes it, then, that the *names* of Linnæus have produced nothing, and that those of Bernard have produced the method? Simply because Linnæus failed to discover the true order, while Bernard discovered and disclosed it.

* To this letter attention is due, as important in the history of Bernard's progress towards the *natural method.* It was necessary to commence by establishing the complete *enumeration* of the *characters,* before proceeding to their appreciation, their relative valuation, the great principle of the *subordination of characters.* This letter is of 1738, the *catalogue of Trianon* of 1759. Bernard does not hurry himself, but he is always advancing.

† To this M. Adrien de Jussieu has subjoined the following: "The catalogue printed in the *Genera plantarum* differs from it in some points: in the suppression of citations and synonyms, the intercalation of certain species written in general by the hand of A. L. de Jussieu, the omission of name in some families, and even the division of some of them. The arrangment of all the hypogynous monopetaleæ is here different, another manuscript, of the date of 1765, having been followed in the printed copy, in relation to this group alone."

Not a few botanists have attempted, as well since the death of Linnæus as during his life, to discover the key of his *names*, the hidden principle of his order, but none has succeeded. Giseke, one of his pupils, had maintained at Gottingen, in 1767, a thesis on the *New systems of botany*, (*Systemata plantarum recentiora*,) and, in reference to the *natural orders* of Linnæus, had said: "Linnæus has written a series of names, but nothing more; no character, no description; a genuine enigma, almost impossible to divine; one knows not why such a plant is placed here, another there, nor what reason has prevailed with the author for uniting or separating them." After some hesitation he sent his thesis to Linnæus, who answered him with his usual good-nature: "You ask of me the characters of my orders, and I confess that I cannot give them."

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Bernard would not have spoken thus lightly of his *orders*, and would not have changed the arrangement he had given them for another, and this because he possessed the key, the reason, the ascertained principle of that admirable arrangement—a principle which, after having carried the *natural method* into botany, has carried it into zoology, and will carry it everywhere; a principle which is to-day so universally recognized under the name of the principle of the *subordination of characters.* "In examining characters," says Laurent de Jussieu in speaking of Bernard, "that botanist had remarked that some were more general than others, and ought to furnish the first divisions. After having appreciated them successively, he had recognized that the germination of the seed and the respective arrangement of the sexual organs were the two principal and most invariable. He adopted them, and made them the basis of the arrangement which he established at Trianon in 1759."

There is, in effect, a visible *succession*, a visible *subordination* of the *organs*, and consequently of the *characters.* In plants, the first rank pertains to the embryo, the end and purpose of vegetation, as destined to preserve the life of the species; the second, to the organs which concur in the formation of that embryo—that is to say, to the stamens and pistils—but taken together and considered in their reciprocal relations; then come the organs which protect these or the other parts of the flower, of the fruit, of the seed; then the secondary modifications of the essential organs themselves, considered separately; and then the organs of vegetation, which contribute only to the individual life. Before Bernard the characters were *enumerated;* since his time, they are *appreciated;* we know, since then, that they have unequal values, that a character of the first rank is equivalent to several of the second, one of these to several of the third, &c. Neither Tournefort, nor Adanson, nor Linnæus had discerned this controlling principle; Bernard perceived it, availed himself of it, and embodied it silently in his *catalogue;* Laurent de Jussieu drew it thence, developed it, and placed it in full light; M. Cuvier transferred it, by giving it wider scope, from botany to zoology; and thus by successive steps we have been endowed with the *natural method.*

§ 5.—*Old age of Bernard.*

"Convinced that principles exist ready formed in nature," (it is Laurent who speaks,) "and that the botanist ought to confine himself to seeking them there, without attempting to establish them apart from nature," Bernard had excused himself from the labor of composing a book. According to him, the perfect book was open to all; it was only necessary to learn to read it. When he found himself intrusted with the *creation* of a botanic garden, he could not fail to experience the liveliest pleasure, for it was the living book, of which he had indulged a dream, that he was now commissioned to produce by arranging plants in the natural order, of which he had discovered the clue. Simply to supply an aid to his memory, he had then composed his *catalogue*, and such is the charm of truth that this catalogue, which is only a long series of barbarous names, became the poetry of a life instinctively devoted to one great task.

Years meantime had accumulated, and Bernard, always absorbed in his problem, perceived the lapse of time as little as he did the renown which had encircled his name. Nothing had altered the serenity of the life of the two brothers; the love of order had, in this house, passed from theory into the most scrupulous practice. To this modest retreat in the *rue des Bernardins* regularly resorted Malesherbes, Duhamel, Lemonnier, Poivre, and other distinguished men, whom similarity of labors and opinions and long attachment united in the bonds of the closest intimacy; here also every learned stranger, particularly every botanist, was emulous of being introduced. The prolonged life of the good Tessier has left to us only the impression of the aged man; here he appeared as the young *debutant.* Andre Thouin was indebted to the two brothers for the origin of his botanical fortunes, and not a few besides, devoted upon similar grounds of gratitude and affection, enlarged the circle by which our *celibataires* were encompassed.

Occupied in scrupulously fulfilling towards his elder brother the duties of a piety which might well be called filial, it is easily imagined with how poignant a grief Bernard was affected when a short malady bereft him of Antoine. He fell into a gloomy reverie, from which nothing seemed capable of arousing him. Seated alone at the once common fireside, his long meditation only then began to be interrupted by bitter reflections. He no longer quitted the house except to go to the church, the *Jardin Royal* or the Academy.

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The protracted life of Bernard condemned him to blindness; but those alleviations which he had ministered to Antoine were in turn supplied to himself by Laurent, the son of their eldest brother, who was, during many of his later years, the inmate of his house. Seated daily near this nephew, and superintending his studies, the old man, under the appearance of a tranquil reverie, became once more absorbed in his former pursuits; it was as a second phase of the same life, as a thought which revives and is perpetuated. Passing away thus, the existence of Bernard may be said to have been at last rather transformed than extinguished; his mortal remains left the fraternal mansion November 6, 1777.

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LAURENT DE JUSSIEU AND THE COMPLETE VIEW OF THE METHOD.

M. de Candolle, in his *Théorie Élémentaire de la Botanique*, undoubtedly the most original and maturely considered of his works, thus expresses himself respecting the two Jussieus: "Without seeking, in any manner, to assign a distinct part to each of these skilful botanists, and to separate names which, united as they were by consanguinity and the most confidential intimacy, will be always still more closely united by fame, we shall merely remark that what characterizes the method of the Jussieus is that it is founded on the subordination of characters." Now, this problem of the distinct part borne by the two, and the proper merit of each, a problem which M. de Candolle has chosen to evade, is precisely that which I propose to consider; but, before attempting its solution, it is necessary to refer to some manuscript *notes* of Laurent de Jussieu respecting his uncle.* It is of interest to see how Bernard was regarded by

* These valuable *notes on the life of Bernard de Jussieu* are accompanied with a notice that "they were intended for instructions to M. de Condorcet." It was, in effect, on these notes that was founded the historical *eloge* of Bernard de Jussieu, read by Condorcet at the public session of the Academy of Sciences of the 29th of April, 1778, and, what added to the *eclat* of the ceremonial, read before Voltaire. At that moment, which so shortly preceded his death, Voltaire was the object of general admiration. "Paris contained at the same time the celebrated Franklin; the latter was naturally desirous of seeing a man whose fame had so long occupied the attention of both the Old and the New World. Voltaire, although he had lost the habit of speaking English, attempted to sustain the conversation in that language,

his nephew, who was at the same time his successor and continuator; without whom we should with difficulty have penetrated the secret of his thoughts or possessed the authentic explanation of his *catalogue*.

"He regarded botany," Laurent tells us, "not as a science of memory or of nomenclature, but as a science of combinations, founded on a thorough knowledge of all the characters of each plant. He compiled, every day, materials for forming that natural order which is the touchstone of botanists. Always thinking himself not sufficiently advanced, he neglected to publish his first essays, and sought the improvement of his work. This distrust of himself continually arrested him, and even brought him to the point of doubting of all." * * * * This last and curious phrase is one which any other than Bernard would scarcely have suggested, and which reveals a species of superiority to which few attain or even aspire. "He wrote little," continues Laurent, "but observed much; and the fruits of his labor would perhaps have been lost to science but for a favorable circumstance, which obliged him to give a practical exposition of his general system in the arrangement of plants." The favorable circumstance was the following: Louis XV having seen at Saint Germain the plantations in which the Maréchal de Noailles had indulged his taste, by collecting the trees and shrubs of foreign countries, was struck with the fancy of forming similar ones at Trianon, and of founding there a school of botany. With this object, and guided by Lemonnier, then first physician of the royal infants of France, he cast his eyes on Bernard, who "being constrained," as Laurent expresses it, "to adopt some arrangement, judged it expedient to substitute his new plan for the ancient methods." Thus we see on how mere a contingency depended our possession of this *new plan;* without the visit of Louis XV to Saint Germain, Bernard would not have been constrained to *adopt an arrangement*, and quite probably would never have written his *catalogue*.

Respecting those ancient methods for which he substituted his new plan, Laurent has conveyed to us the views of his uncle: "Those methods were, according to him, only descriptive tables in which the plants were arranged agreeably to a conventional order adopted for the convenience of those who study them. The science, limited to these methods, is a factitious science, very remote from that of the natural order, which is the true one, and which consists in a knowledge of the real relations of plants and their organization." * * * * "When a man," adds Laurent, "has combined the characters of plants to such an extent as to be able, in an unknown species, to determine the existence of many from the presence of a single one, to refer on the spot this species to the order which suits it; when he has destroyed the prejudice, so disparaging to botany, that it is to be regarded as a science of memory and nomenclature, and has made of it a science of combinations which affords aliment to thought and imagination, that man may be called the creator, or at least the restorer of the science. Others will, perhaps, extend its bounds, but he will have been the first to point the way, to trace the plan, to establish the principles. M. de Jussieu has not, it is true, consigned them to any book, but in the garden of Trianon we recognize the conception of the author. The same conception reigns in the recent arrangement of the *Jardin Royal* of Paris, formed upon the model of that of Trianon, and only differing from it in some points for greater facility of study." Finally, Laurent arrives at the higher view which characterizes the Jussieus in botany, at the key which has given them the natural order, the principle, namely, of the *subordination of characters*. "In the examination of characters, Bernard had remarked that some were more general than others, and should furnish the first divisions.

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but presently resuming his own: I could not resist the desire (he said) of speaking for a moment the language of M. Franklin. They met again at a public sitting of the Academy of Sciences; they here embraced amidst the acclamations of the spectators, who exclaimed that it was Solon embracing Sophocles." (Condorcet: *Vie de Voltaire.*)

After duly considering their relative value, he recognized the germination of the seed and the respective arrangement of the sexual organs as the two principal and most invariable; he adopted them, and made them the basis of the arrangement which he established at Trianon in 1759."

Thus the solution of the problem I had proposed is seen to have little difficulty; for Laurent himself tells us, as well in these notes as in the preface to his *Genera Plantarum*, that it is to Bernard we owe the discovery of the principle of *subordination of characters*. "This inequality of characters had not escaped the excellent author of the *Orders* of Trianon, neither the subordinate part of the more variable, nor the importance of the more constant, nor the dignity of the embryo and the sexual organs, nor the affinity of the genera and orders which are associated with one another by these primary indications. The families which he has established are, in general, strictly natural, and conformable to these principles." At a still later period, he styles the *Catalogue of Trianon*, that mature result of the long meditations of Bernard, "the most solid monument of his renown." Nor does M. Adrien de Jussieu, though disposed by a natural bias to incline the balance rather to the side of his father than his uncle, bear a different testimony: "I have beneath my eyes the manuscript catalogues of Bernard: there are two of them; that which was printed at the head of the *Genera*, and another still longer, in which are enumerated, in connection with the name of each kind, the species according to the Linnæan nomenclature, with a brief synonomy of former authors. But the whole is limited to a series of names, without a word of development or explanation. Such as they are, however, they evince that Bernard de Jussieu had established the principle of the subordination of characters, and had determined those to which must be assigned the first rank; an immense step in advance, and sufficient in itself to immortalize him who conceived it." * * * * "But does this embrace," asks M. Adrien with reason, "all that we find in the *Genera Plantarum?*" In reply, let us briefly examine that work. At the time of its appearance, botany possessed 20,000 plants, of which more than half had been unknown to Bernard—those of Commerson, of Dombey, of Forster, of Forskal. The author distributes these 20,000 plants into a hundred orders; these hundred orders into 1,754 genera;* to each of these orders and genera are assigned its characters, and to all these characters their due valuation and weight.

The author divides the characters into three classes: The first class, essential, constant, uniform in all the orders, and drawn from the most important organs, the number of lobes or cotyledons of the embryo, the insertion of the stamens or their arrangement in relation to the pistil, the situation of the staminiferous corolla; the second class, general, nearly uniform in all the orders, or only varying by exception, and drawn from organs less important—the presence or defect, whether of the calyx or of the non-staminiferous corolla, the structure of the corolla considered as monypetalous or polypetalous, the relative situation of the calyx and the pistil, finally the presence or absence of the perisperm; the third class, sometimes uniform and sometimes variable, now furnished by one organ and now by another, the calyx monophyllous or polyphyllous, the ovary simple or multiple, the number, proportion, connection of the stamens, the number of cells of the fruit and its manner of opening, the position of the leaves and flowers, &c., &c. By virtue of this classification of the *signs*, Laurent has always before him the principle which controls the arrangement of plants. It only remains to respect everywhere this first classification, which gives the other. Let no character of a genus intrude into the definition of an order, nor of an order into the definition of a genus. The least inversion produces dissonance in the natural order. By this system the method is seen, more clearly than ever before, to be the *science of characters*. There are found to be laws by which these characters

* Add 150 genera which are *supernumerary*, or of doubtful place (*plantæ incertæ sedis*.)

imply or exclude one another; the presence of a single one, as we have already heard Laurent say, suffices to determine the existence of many, and it is even in this that the most distinctive feature of the method reveals itself.

Adanson* and others, who censured Laurent for this exclusive preference given to one part among all the rest, were completely at fault. They failed to appreciate that wonderful correspondence through which a character, aptly chosen, far from excluding others, as they apprehended, comprises, implies, involves them, as its consequence, and in proportions always definite, in combinations always fixed. They failed to perceive those subordinations, those obligatory connections, or, as Cuvier at a later period called them, those necessary *correlations* of parts, which enable us from each to infer the whole, and reciprocally from the whole to infer each—a singular prerogative inherent in the *natural method*, and which that method, among all others, alone possesses. But by what process had Laurent elevated himself to a knowledge at once so thorough and original, to what might almost seem an instinctive appreciation of characters? Doubtless the catalogue of Trianon had been his first guide, the counsels and conversation of Bernard his earliest and most valued resource. But in the following extract from a short manuscript account of himself, which lies before me, we obtain an insight into the means he had devised for rendering this knowledge peculiarly his own.

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"In 1773," he says, "a place of botanist being vacant at the Academy of Sciences, I was tempted to compose a memoir in order to be admitted to it, and with a view to understand thoroughly what are called families, I determined to take one of them as the subject of my essay. Linnæus had published his *Fragmenta Naturalia* or *Ordines Naturales;* Bernard de Jussieu had arranged his *Familles* in the garden of Trianon, and Adanson had published his *Familles des Plantes* in 1763. I selected for a subject the family of the Ranunculaceæ, adopted by these three authors, and after having studied their catalogues, I reviewed this family in all its characters, and soon recognized that these had not all the same value; that some were constant in all the plants of the family, that others varied only by exception, and that others again were more or less variable; whence I concluded that, in comparing them, it was not sufficient to have regard to the number of like characters, but that it was necessary to take into account their unequal value: thus it was that the seed furnished me the first values, the sexual organs, taken together, the second, and the other characters, successively diminishing in proportion, gave me finally more definite ideas on these relations. My memoir, composed by myself alone, but approved by my uncle, was accepted by the Academy and opened its doors to me in March, 1773."

This work on the characters of the *Ranunculaceæ* being finished and published, Laurent immmediately commenced a similar one on the *Compositæ*, the *Gramineæ*, the *Leguminosæ*, the *Umbelliferæ*, &c., families alike natural by the consent of all botanists; and, this completed, he felt that he was master of the science.

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* "The principles of M. Jussieu," says Adanson, "will encounter perhaps some difficulty on the part of botanists who believe that a method, in order to be natural, should found its divisions on an examination of all the parts taken together, without giving to any one an exclusive preference over others." (Report of Adanson to the Academy on the first memoir of Laurent de Jussieu.)

Adanson was, after Bernard de Jussieu, the man of his time who had given most attention to *method*. In his elaborate work, *Families des Plantes*, he remarks: "In the artificial methods, of which the object was simply to render more facile a knowledge of plants, by disentangling it from the multiplicity of characters, consideration was given to but one or a few of the more general or prominent parts of the fructification, but, in a natural method, the characters, whether of the class, the genus or the species, ought to be taken from all parts, more or less obvious, of the plant." Laurent de Jussieu having one day read a memoir to the Academy, Adanson abruptly remarked that he recognized therein several ideas which he had himself already made public. "I can well believe it," was the calm reply of Laurent; "we studied under the same master." Adanson had, in effect, studied under Bernard; moreover, the plantation of the garden of Trianon dates from 1759, while the *Families des Plantes* appeared in 1763.

"From that time," he says, "I conceived the plan of a new classification; * * I projected, upon these principles, a new method, whose entire plan is set forth in my memoir of 1774; I combined together the labors of the three authors before cited." * * * * * At length, in 1788, after fifteen years of this persistent labor in the study of characters, the printing of the *Genera* commenced. The author was so full of his book that he began to print without having written it, or, as he himself says, "it was sent to press in proportion as it was composed." It appeared in 1789, under the title: *Genera plantarum secundum ordines naturales disposita, juxta methodum in horto regio parisiensi exaratam.*

Now that both Bernard and the *Genera* are known to us, may we not say with confidence that Bernard would never have taken upon himself the execution of so laborious an exposition? He loved truth, but sought it only for the satisfaction it procured him. On a nature of so much simplicity neither vanity nor ambition had any hold. In 1758, after the death of his brother Antoine, whose sub-demonstrator he had been, it was proposed to him to be advanced to the first place; he preferred to retain the second: "The old," he answered, "are content with what they have; they do not like change." In 1770, Lemonnier, the successor of Antoine, being appointed first physician to the king, and hence obliged to reside at Versailles, it became necessary to find a substitute; Buffon referred the nomination to Bernard, who presented Laurent. Very different in this respect from his uncle, the latter accepted the charge, though then only twenty-two years of age and nearly ignorant of botany.

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"It was now time," he tells us, "that I should apply seriously to the study of the science; the method of Tournefort, then taught in the garden, was, it is true, very easy, and the students were novices; there was little difficulty in retailing to them in the morning what I had acquired the evening before. My uncle, who had always arranged the plants, whether for his brother Antoine or his successor Lemonnier, rendered me the same service, and, in the earlier lessons, supplied me with the characters of the principal species." When Bernard, in 1770, fulfilled this part of sub-demonstrator to his nephew of twenty-two, he was himself seventy-one years of age; no circumstance perhaps could more strongly mark the difference of their respective characters.

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LIFE OF LAURENT DE JUSSIEU AND INFLUENCE OF HIS LABORS.

It has been seen that Antoine Laurent de Jussieu, born at Lyon April 12, 1748, and adopted by his uncle Bernard in 1765, at once became, under the direction of the latter, a master in science. The explanation of this is, that having been guided by the impressions he received into a path at once true and untrodden, all the steps which he took were naturally confident and progressive.

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In the memoir which procured him, at the age of twenty-five, admission to the Academy, he had laid down the principle "that, without neglecting the nomenclature, it was above all necessary to devote attention to the investigation of characters, the most important part of botany." This was one of the truths which had occupied the life of Bernard, and now proclaimed by Laurent, it challenged general recognition at the moment when it had become most necessary to the progress of the science.

In 1774, he presented, in a second memoir, written on occasion of the reorganization of the botanical school of the *Jardin Royal*, the plan of a new classification. This new frame-work of the science, a skilful combination of the labors of Bernard at Trianon, of the method of Tournefort and of the nomenclature of Linnæus, was developed with a precision and confidence which struck all considerate minds, and established Laurent as an innovator at the Academy and

among botanists. In this memoir he lights the torch destined to guide all the great labors upon method executed during his era. I cite the following passage: "There exist in vegetables, as in animals, primary classes which comprise other secondary clases; both are founded on general and invariable characters, which can only be derived from the organs most essential to life, and the reproduction of the species; all beings which differ in the structure, situation and function of these principal organs ought to be separated; hence the first divisions of the animal kingdom result from the inspection of the heart, the number of its ventricles and auricles. The organs, which hold after this the first rank in the animal economy, will give the second divisions, and so on. This principle, from which no departure can be made without lapse into error, is the foundation of all researches in organized bodies; nothing conclusive can be obtained from the examination of the external parts, of those parts which supply, at most, characters of the third or fourth order; methods founded on these characters always deviate from nature, both in the animal and vegetable kingdoms.

"These truths," he continues, "did not escape my uncle, and the arrangement of families, in the garden of the *Petit Trianon*, proves that he was thoroughly penetrated with them; his order is more natural than the methods published up to this time, because it is simple in its general divisions, and preserves the integrity of families. We find there the three primary classes, characterized by the embryo; the *acotyledons* are arranged according to the more or less marked appearance of the parts of fructification; in the *monocotyledons* the author is guided by the insertion of the stamens, and successively passes in review the stamens borne on the pistil, those which adhere to the calyx, and those which are attached to the support. The *dicotyledons* are divided, likewise, by observing that, when the corolla bears the stamens it is their insertion which becomes the decisive character in referring the plants to one of the three insertions of the stamens."

For his classification Laurent takes from Linnæus, as we have already seen, the *genera*, the *species*, the *nomenclature;* from Bernard, the *orders*, or *natural families;* from Tournefort, a means of multiplying the *classes* of Bernard, without breaking up his *orders* or his *families*. The *genera* of Linnæus were the most precise which had yet been known; his *species* the most definite; his *nomenclature* was admirable. This nomenclature, which reduced the long phrases of Tournefort and Gaspard Bauhin to two words for each plant, the name of the species and the name of the genus, constituted in itself a great reform in the science. Yet when the question arose of introducing it at the *Jardin des Plantes*, a difficulty occurred; Buffon, who was then intendant, rejected the Linnæan names simply because they were those of Linnæus. A little reflection, however, recalled him to a sense of right, and the Garden received at the same time the nomenclature of Linnæus and the natural order of Bernard. A year later, instruction was given only according to the new method. The presence of Bernard, coming every morning to arrange the plants for the lectures, lent a sanction to the development given by the young chief of the doctrine to the thoughts which had been suggested to him by the old one.

A science whose progress strikes the imagination is sure to attract a throng of proselytes. Never had botany counted so many. The expeditions into the country, to which Bernard had imparted so much interest, and which Linnæus, by adopting them, had rendered still more famous, had now no other guide than Laurent. Each spring-time saw the train which accompanied him increase in number; neither age nor celebrity stood aloof, for the same attraction captivated all minds however different their predilections. There might be seen the youthful son of a procurator, escaped from the jargon of the paternal office, who merely skimmed the surface of botany preparatory to a bolder flight in another science, through which he would one day endow his country with the glory attached to the name of Lavoisier; or it might be Raynal, coming to seek the scientific details embraced in his history of the two Indies. We have already

seen Jean Jacques Rousseau ask from Bernard directions for the studies which consoled his latter years. For five seasons, the author of *Emilius* assiduously followed the herborizations conducted by Laurent, and often succeeded in turning their course towards Montmorency. De Jussieu, fascinated by the blandishments of the distinguished man, complied the more readily with his wishes on such occasions, because a compact existed between them which interdicted all allusion to the works of the philosopher, and under this condition the latter showed no want of the qualities of a gay and complaisant companion.

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Let us return to the two memoirs, which may be considered as the basis of all that was effected by Laurent in the sequel.* They had been written while Bernard and Linnæus were alive; a few years had elapsed and the two patriarchs of botany were no more. Thenceforward the first place was open, and all felt that it was Laurent who must occupy it; it was impossible that he himself should not feel it. Accordingly, we find in a letter of his, written about this time, these noticeable words: "There are circumstances of which it is our duty to take advantage, and one offers itself to me which I should be wrong to neglect. We have lost, within three months, the three first botanists of Europe, M. Haller in Switzerland, M. Linnæus in Sweden, the third at Paris. It would be a proud thing to succeed them, and to retrieve for France the pre-eminence which foreigners have disputed." These words evince the consciousness which he felt in his own strength; what still more evinces it is the labor which he then projected of comprehending the entire vegetable realm within the principles which he had just established in his two memoirs; a vast enterprise, resulting in his great work on the *families of plants*, the celebrated *Genera Plantarum* which we have already had under consideration.

In this admirable production a circumstance especially worthy of remark is the use which the author has known how to make of the materials within his reach at the time of its composition. Their number has since been increased fourfold, and yet there is no great principle of the natural order which is not laid down in his book, and scarcely any of the combinations established by his successors of which the germ is not to be found. Fontenelle admires in Tournefort a classification in which twelve hundred new species, which, he adds, *no one expected*, have found admission without disturbance of the plan. What would he have said of the method of M. de Jussieu, in which nearly fifty thousand species, unknown at the moment he wrote, have found their place, and almost everywhere a place indicated in advance, a place which expected them?

I have said that the author had established a hundred primitive families; none of these has been suppressed; more than half have undergone no modification. Three have been transferred, and transferred entire, into neighbouring groups, which is but a different mode of association. Of the others, the greater part, through the natural effect of so many new species collected in the lapse of nearly half a century, have been necessarily disintegrated and subdivided; but scarcely one has been so, except by sections or divisions indicated by Laurent himself. Finally, there are five, and only five, of them which have been recognized as natural only by fragments. Hesitation then exists only respecting some fragments of families, some scattered species, and even here there is rarely ever wanting a note, an indication, a doubt, pointing in the direction of the truth—truth which only the most wonderful sagacity could then have descried, so few were the elements at hand from which to deduce it, and so great the need of since collecting new ones, in order to establish it in a complete manner.

Systems grow more sacred with age, and the promoter of the natural method lived long enough to see it almost universally adopted. Desfontaines not only taught it, but rendered it essential service by an important discovery in vege-

* For the note, which, in the original, is appended to this passage, the reader is referred to the end of the article, whither it has been consigned on account of its length.

table anatomy. Richard, who first applied exact and detailed analysis, was often associated with Jussieu in his labors. I find a memoir inscribed by him to the latter in the words, *To the greatest botanist of Europe;* and no one who ever knew Richard will suspect him of flattery. The penetrating and critical spirit of Du Petit-Thouars found nothing to censure; De Candolle, Mirbel, Robert Brown have developed the method in their writings; Humboldt has applied it to botanical geography; the pupils reared by them, and the generations which have succeeded, have all rallied under its laws. Intelligent acquiescence has in this been only equalled by the docility with which vegetable nature has enlarged by thousands of species the outline originally traced, without permitting an infringement of the ordinances of the lawgiver.

In 1793, the *Jardin des Plantes* received a new organization, and took the title of Museum of Natural History. Daubenton was the first director, and was succeeded by De Jussieu. In those difficult times, he devoted himself entirely to the administration of this admirable establishment. The libraries of the religious bodies having been suppressed, he obtained leave to select from them all that had a bearing on natural history, and thus laid the foundation of the present rich collection of the Museum. Nearly always secluded in his cabinet, he had remained a stranger to the political agitations which then convulsed France; it had even been a subject of public reproach that he never appeared in the popular assemblies. He judged it expedient therefore to repair to his section, which was that of the *Sans Culottes.* It was the day for choosing a president, and, to his amazement, he found himself promptly promoted to the honors of the chair. From this time municipal dignities were showered on him; dignities which it was dangerous to refuse, however earnestly he might covet the retirement of his garden. Yet, in the exercise of functions thus unexpected, his spirit of order and method suggested to him a *report on the hospitals of Paris,* which is still regarded as a model.

As a relaxation from severer studies, M. de Jussieu applied himself to the compilation of *Memoirs of the Museum,* an exact and complete history of men and things. We there see the origin of the *Jardin Royal,* which was at first but a garden for medicinal plants; this was indeed its legal title, its cabinet being but a depot of drugs. In tracing the successive steps by which it has become the most magnificent of collections, its historian recalls the difficulties of every sort which were to be surmounted for the establishment of instruction in natural history, independent of that in medicine, and the petty war which it was necessary to sustain against the Faculty, who could not tolerate the introduction of chemistry, the object of one of the new chairs, into the course of instruction, *as being,* (so said the Faculty,) *for good causes and considerations, prohibited and denounced by decree of Parliament.*

In 1804, the chair of *materia medica* in this same Faculty, having become vacant by the death of Peyrilhe, M. de Jussieu offered himself,* and all competition disappeared. As professor, he took for the basis of his lessons the fruitful principle of the correspondence of the properties of plants with their botanical affinities.† "Reasoning, founded on experience," he had said in his memoir of 1774, demonstrated that plants conformable in their characters possess the same

* He had, in 1766, taken a very active part in the formation of the Royal Society of Medicine, and ably seconded the efforts of his friend Vicq d'Azyr, to found and sustain a body, then so strenuously combated by the old Faculty, and which, at a later period, became the nucleus of the new Faculty.

† The development of this principle forms the basis of the discourse which he read at the public meeting of the *School of Medicine* in 1806. It is curious to see this important principle already distinctly enunciated by Morison: *Plantæ quæ generis societate junguntur plerumque et similes possident facultates,* (*Plantarum Historia, &c.*) But it should be remarked that this principle has only become really serviceable to the materia medica, when it has been practicable to apply it to groups more comprehensive than the *genera,* to orders, namely, or *families.*

properties, so that, the natural order being once given, it will be practicable to *determine their virtue by exterior signs.*

During the latter half of his life it was his most cherished purpose to give a second edition of his principal work. Unfortunately he was able to leave but fragments of these labors, all, however, of a singular completeness. They form a succession of memoirs, inserted, almost uninterruptedly, from 1804 to 1820, in the *Annales du Museum.* Here more than half the primitive families of the author pass in review, each is examined in detail, and in each the species which compose it. The great work of Gærtner *on fruits* was not available to him in 1789. He now takes it as a term of comparison, as a touchstone, so to say, of the new groupings which he proposes. In studying the seed Gærtner had brought anatomy to bear upon the same organ, from which M. de Jussieu has drawn the principal bases of his method. Applied to the science of relations, the observations of Gærtner acquire an unexpected importance, and they are taken advantage of by De Jussieu to throw new light on the computation of characters, on the formation of families, on the art, but little known before, of adapting to one another those two resources, on which depended thenceforth the advancement of the science—anatomy and the method. Numerous articles, scattered through the *Dictionnaire des Sciences Naturelles*, are also important productions, and, collected in a single work, would form one of the most useful of books upon botany. The article *Methode naturelle* is a second edition of the *introduction* to the *Genera Plantarum*; that upon *families*, though much shorter—since much would have been only repetition—is a model in its kind. The articles relative to each particular family all present, and in proportions required by the subject-matter, the same brevity, the same precision, the same definite views of the facts composing them. Lastly, those of which the object is the determination of the *names of plants*, as reported by travellers, exhibit his sagacity under a new aspect. These names, barely accompanied by a few vague and incomplete indications, were so many enigmas which piqued his curiosity, and in the search for whose solution he found a sort of learned diversion.

The philosophic tranquillity of his spirit had taught him the secret of sparing himself unnecessary trouble. When attacked, as he was in almost all languages, he never replied. "If I am mistaken," he would say, "it is natural that I should be attacked; and if I am not, all attacks will be futile." He never ceased to refer the greater part of his success to his uncle. A stranger was once congratulating his son on the good fortune of bearing so honored a name; "Yes," replied M. de Jussieu, who was present, "it has been a very useful one to me."

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A very decided myopy was common to all the members of this family who devoted themselves to botany. Laurent, whose sight had always been weak, lost the use of one eye while he was yet in the prime of life, and towards the close of his career the other became so enfeebled as to allow neither of writing nor observing.

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In advanced age he passed a part of the year in the country, still finding his chief pleasure in the search for plants, which, while some degree of vision remained, he recognized by bringing them close to his eye, and, when he could see no longer, by the application of touch. To succeed under such circumstances pleased him as a sort of triumph. At the creation of the Institute he became naturally one of its members. He was nominated to the Council of the university in 1808, was for sixty-three years a member of our Academy, and for sixty-six years a professor at the Jardin des Plantes. His constitution was robust, his stature tall; his gait and whole bearing denoted the self-possession of a profoundly thoughtful man. The simplicity of his tastes, the habit of labor, the tender cares of a devoted family, secured to him a long and vigorous old age. He expired September 17, 1836, in the midst of the most cherished objects of his affection, at the age of 88 years.

ADRIEN DE JUSSIEU.

In this sole and last direct inheritor of the name of Jussieu were early manifested a singularly just and acute discernment, a certain archness of humor, and a sentiment of profound respect for his progenitors. To these was added a thorough and very comprehensive instruction. M. Adrien had recognized and resolutely accepted the great weight imposed on him by the celebrity of his ancestry. His works, stamped with merit of a high order, attest even by their small number, due to his scrupulous regard for excellence, a respect for his predecessors and himself. Some of his memoirs * are finished models of that complete and profound study of families which embraces not only all that belongs to the formation of groups, but all that relates to vegetable anatomy, physiology, and geography. His *Traité Élémentaire de Botanique* supplies the most substantial, precise, and at the same time most elegant survey of the actual state of the science, while his article *Taxonomie*, in the *Dictionnaire universel d'Histoire Naturelle*, is the most well-considered and profound disquisition which has been given, in our day, on the important subject of *Methods*.

His father, who had relinquished to him his chair at the museum in 1826, had the satisfaction of seeing him, in 1831, take a place beside him at the Academy. The herborizations, which his great-uncle Bernard and his father had rendered famous, were continued by him. In 1845 he was designated to fill the chair of vegetable organography at the Faculty of Sciences. His pupils will not readily forget with how much skill all available knowledge was condensed in his lessons. He had been long collecting the materials for a history of botany, and it cannot be too much regretted that his protracted sufferings did not permit him to finish it. Never has an historian been more happily adapted to his task. For such a work he possessed at once clear-sightedness, discrimination, and profundity of knowledge. His colleagues and friends have still in lively remembrance the vivacity and originality of his conversation, the humorous and graphic turn of his mode of narration. M. Adrien had religiously cultivated the domestic virtues, which were traditionary in his family, and which contribute so much to the happiness of life. His veneration for his father was almost idolatrous, while his devotion to the two daughters, who survived him, was not less marked by features of the most tender and judicious regard. He died June 29, 1853, aged 55 years, having been born December 23, 1797.

Note to page 23.

All that M. de Jussieu has produced may be regarded under two chief points of view: *character* and *classification*. It was with his memoir of 1773 that he opened the study of the former, and in that of 1774 that he laid down the principles of the latter.

§ 1. *Of characters.*—Characters are the signs which indicate the relations of beings. In every organized body, whether animal or vegetable, each part has necessary relations with all the others. We may therefore judge of all by each. And those parts which are thus taken for *signs* of others, those parts by which we judge of others, are what we name *characters*. Naturalists had begun by seeking these *characters*, these *signs*, almost indifferently in all the parts. It was subsequently recognized that these different parts are very far from having an equal value either in uniting or separating beings. Thence has sprung the valuation of characters, and this valuation has furnished the solution of the problem of method.

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* Especially those on the *Euphorbiaceæ*, (1824,) the *Rutaceæ*, (1825,) the *Meliaceæ*, (1830,) the *Malpighiaceæ*, (1843,) &c., and lastly, his fine treatise on *Monocotyledinous embryos*, (1839.) I here but indicate his labors; the time for their complete appreciation has not yet arrived.

Everything depends, then, on the principle of the *relative importance* of characters. But how is this relative importance to be learned? By two means equally sure, and which M. de Jussieu has himself explained: one, founded on reasoning, infers directly the *importance of the character* from the *importance of the apparatus* which furnishes it. Everything in the vegetable tends to the formation of the flower; everything in the flower tends to the formation of the embryo, of the new being; the formation of this new being, the embryo, is therefore the aim and end of all the other vegetable functions. "It is in the embryo, then," says M. de Jussieu, "that naturalists must seek their principal characters." *(Dict. des Sc. naturelles,* article *Methode naturelle.)* In his memoir of 1774, he had said: "A different conformation in the vegetable embryo occasions, in the development and organization of the plant, remarkable differences, which constitute so many characters; these differences being dependent on those of the embryo, the characters which they give depend equally on a single one which determines their existence; whence it follows that the character derived from the embryo must have a value equal to that of all the others united.

So much for the first means, that founded on reasoning—the *rational* means. When this fails, M. de Jussieu supplies it by another purely *experimental,* and which never fails. In defect of the function which is not known or is badly known, he determines the *importance* of the organ by its *constancy.* Nor is this all; it is with each circumstance of an organ, as with the organ itself: the circumstance the most *constant,* that is to say, the most general, is always the most *important.* Linnæus has made of the stamens the base of his system; the number, attachment, union, proportion, situation of these parts, are all considered, all employed; and he does not see that, among all these characters, one only has importance, because it alone has constancy, namely, the *attachment* of the stamens, or their insertion. Tournefort has founded his system on the corolla. He considers the absence, presence, situation, division, form of the corolla, and employs all these characters which are variable, while he neglects precisely the character derived from the *attachment* of that organ, which alone is constant. The natural order has escaped both these sagacious men, and has escaped both from the same cause, because of their not having recognized the *relative importance* of characters. Still further, if we take the botanists from Gesner onward, all those who have been fortunate in their attempts, who have discerned some fragments of the natural order, all, without knowing it, were guided by the principle of the *importance of characters.* Yet more, there are natural families already formed, such as those of the *gramineæ,* the *compositæ,* the *umbelliferæ;* if we study these families, every character which varies in the family is subordinate, is secondary; the primitive and essential character, the important character, embraces the entire family. There is, therefore, a *gradation,* an *order* in characters; and, as I have elsewhere said, the true problem is to begin by classifying these characters, according to which the objects, in turn, are classified.

But it will be said, perhaps, and with reason, are the *important* characters always accessible, always easy to be determined, to be seen; and then how shall we be governed in reference to the inferior, the accessories? To know this, we need only refer to M. de Jussieu: "All the characters," he says in his memoir of 1773, "have not the same value, the same efficacy in uniting or separating plants. Some are primary, essential in themselves and invariable, like the number of lobes of the embryo, its situation in the seed, the position of the calyx and the pistil, the attachment of the corolla and the stamens; these serve for the principal divisions. The others are secondary; they sometimes vary, and only become essential *when their existence is intimately connected with that of the preceding;* it is their assemblage which distinguishes families. It is true that the fundamental characters of any order whatever should always be taken in the fructification, but at the same time it is necessary to regard those which

the other parts furnish, as accessory characters, *which announce the existence of the preceding*, whose minuteness or situation sometimes hinder them from being remarked. It is thus that, among animals, the external disposition of the parts indicates the number of ventricles of the heart and other distinctions of the class or genus." Lastly, in his memoir of 1774, he says: "Characters simply general are usually connected with some of the essential characters, a circumstance which affords accessory signs *announcing the existence of the true characters;*" and, with reference to the organs of animals, he adds: "He who should content himself with exterior or secondary signs *without establishing their affinity with the interior parts*, would have but an imperfect idea of the true relations which exist between animals." There is profound analysis in these observations, and equally true whether it be applied to zoology or botany.

§2 *Of classification.*—Let us first consider the classification of Bernard, as stated by M. Laurent de Jussieu: "The *orders* traced by Bernard in the garden of Trianon amount in number to sixty-two, more than half of which are entirely conformable to actual families. Several others, likewise conformable, differ only by the addition of strange species which ought to have been detached. Others, still, are a union of several families, which should sometimes remain united, sometimes be more or less separated. The author, having given only a simple manuscript catalogue, without other addition, has not characterized his orders nor assigned the reason of their arrangement. But if we carefully study that arrangement, we first recognize that, without indicating the classes, he has adopted the three great divisions characterized by the embryo. The first orders pertain to the *acotyledons*, excepting, however, the *naïades*, which have been separated more recently; and the *aristolochiæ*, which should be completely separated. In the *monocotyledons*, which follow, there are seen to appear successively the orders with *epigynic* stamens, those with *perigynic* stamens, and those with *hypogynic* stamens, which proves that he appreciated the characters derived from the insertions. In the *dicotyledons* he pursues the same course, the same distinction, though concluding with the *perigynic* plants, and referring to each the *monopetalous, polypetalous, and apetalous* plants, which have the same insertion, sometimes intermingled, sometimes following one another separately. He terminates his series by the *amentaceæ* united to the *urticeæ*, the *euphorbiaceæ* and the *coniferæ*. It will be seen that, without having proclaimed the natural laws, he has almost always silently obeyed them." (Article *Methode naturelle* of the *Dict. des Sciences Naturelles.)*

Bernard, then, had established sixty-two *orders* or natural *families;* and having done this, he had united these sixty-two orders into seven classes. "The animal kingdom" says Laurent in his memoir of 1774, "has but seven classes; in following the divisions of Trianon we count no more in the vegetable kingdom." This number of seven results in effect from the employment of the *insertion of the stamens* alone for the subdivision of the *monocotyledons* and the *dicotyledons.* We have, then, three classes for the monocotyledons, three for the dicotyledons, making *six;* the acotyledons, left undivided, because their flowers, so little apparent and little known, form the *seventh.* Laurent felt the necessity of multiplying these *classes*, and availing himself of the *corolla*, (a resource which Bernard denied himself,) raised their number first to fourteen, and then to fifteen. "The author of the order of Trianon," he says, "regarding this work as proper for botanists alone, as an advance towards perfection, and a simple indication of the route which should lead to it, desired that, to satisfy the present object, which is that of public instruction, we should labor rather for learners than for adepts; that, without deviating from the true principles, we should seek to establish a method which should have the classes in greater number, more precise, and consequently more easily to be apprehended. He thought, further, that it was incumbent on him to comply, as far as possible, with the received prejudice which regards as the preferable method that which is founded on the parts

more apparent and easy to be observed. It has been thought that this double object might be fulfilled by joining to the essential characters, which are sometimes little apparent, certain accessory characters, which are constant and always visible, and which indicate the existence of the former by associating the corolla with the stamens, in order to designate the classes." (Memoir of 1774.)

Laurent has since said, (1824:) "It would be necessary to adhere to this number" (the number *seven* of Bernard,) "if, in order to avoid all exception or variation, the classes could only be founded on invariable characters. But if it be observed that the number of families now adopted amounts to nearly one hundred and fifty, and is consequently quite considerable for each class, the necessity will be felt of forming new subdivisions, without deviating, however, from admitted principles, and by always adhering to characters of the greatest value. That which first presents itself, after the invariable, is the character derived from the mediate or immediate insertions, or, otherwise, from the corolla considered as existent or null, as monopetalous or polypetalous. Although it be subject to some variations, it is still that which presents the fewest, and by employing it for the subdivisions, the number of classes can be multiplied, which diminishes embarrassment in the arrangement of families, and may much facilitate study. It is true that this character is of no utility in dividing either the acotyledons, the flowers of which are too little apparent, or the three classes of monocotyledons, in which the corolla does not exist, since the part which was long taken for such is a true calyx. It is in the dicotyledons alone, then, that we can employ the character of the insertions, whether mediate, simply immediate, or essentially immediate; or, in other terms more easily remembered, the character of monopetalous, polypetalous, apetalous plants. We thus establish, though admitting of some exceptions, in each of the three classes of dicotyledons, three subdivisions, without deviating from the principles adopted, and the number of dicotyledinous classes would then be raised to nine. Further, the subdivision or class of monopetals with epigynic corolla, or corolla borne on the pistil, may be separated into two, according to the character of their stamens, distinct in one of its divisions, united in a sheath by the anthers in the other, which comprises solely the great series of composite plants. This separation, which, in the dicotyledons, adds a tenth class, does not separate families and conflicts with no affinity."

He afterwards adds: "It has already been stated that, in order to arrange the families more easily, it was necessary to multiply the great divisions, always adhering, however, to the most solid characters, and we have seen how it has been practicable to augment this number of classes in the dicotyledons through considerations derived from the corolla. It has appeared to us, nevertheless, that, with a view to facility of study, an object which should not be neglected, it was necessary, in order to have in the great divisions principal characters easy of apprehension, and to approximate a little in this point to the method of Tournefort, founded on the corolla, to give the preference to mediate and immediate insertions over hypogynic, perigynic and epigynic insertions, and not to follow rigorously the first principles established. We shall have the same classes, but presented, in the dicotyledons, according to another series. Thus, by leaving the four classes of the first two grand divisions to subsist in their integrity, and without any change, we shall, in the first place, distinguish the dicotyledons into apetalous, monopetalous and polypetalous plants. In the apetalous, or those with essentially immediate insertion, we shall distinguish three classes with epigynic, perigynic, and hypogynic stamens. If we next pass to plants with a monopetalous corolla or mediate insertion, and if we remember that the insertion of this corolla then becomes the essential and primary character, we shall subdivide the monopetals into the hypogynic, perigynic and epigynic corollas, and the epigynæ will be further divided into synantheræ, having united anthers, and chorisantheræ, having distinct anthers. The polypetalous plants, or those having the insertion

simply immediate, will be divided, like the apetalous, according to the insertions epigynic, hypogynic, and perigynic of the stamens, without any further subdivision. The class of *diclines* will close this series of eleven classes, which, joined to the four preceding, will carry the whole number to fifteen, in which we can arrange all the families known, without decomposing them." (Article *Methode naturelle* of the *Dict. des Sciences Naturelles.*

The following is the table of these fifteen classes given by Laurent himself in the article just cited:

ACOTYLEDONES				*Acotyledones*	1
MONOCOTYLEDONES		stamens hypogynous		*Monohypogynæ*	2
		stamens perigynous		*Monoperigynæ*	3
		stamens epigynous		*Monoepigynæ*	4
DICOTYLEDONES	APETALÆ	stamens epigynous		*Epistameneæ*	5
		stamens perigynous		*Peristamineæ*	6
		stamens hypogynous		*Hypostamineæ*	7
	MONOPETALÆ	corolla hypogynous		*Hypocorolleæ*	8
		corolla perigynous		*Pericorolleæ*	9
		corolla epigynous	anthers united	*Epicorolleæ* / *Synantheræ*	10
			anthers distinct	*Epicorolleæ* / *Chorisantheræ*	11
	POLYPETALÆ	stamens epigynous		*Epipetaleæ*	12
		stamens hypogynous		*Hypopetaleæ*	13
		stamens perigynous		*Peripetaleæ*	14
	DICLINES			*Diclines*	15

In the table placed at the head of the *Genera Plantarum*, instead of the names which here indicate each class, the author had merely employed the number, a mode of designation which, as is seen above, he judiciously changed.

INDEX METHODI

Ordines naturales complectentis.

ACOTYLEDONES				Class I
MONOCOTYLEDONES		stamina hypogyna		II
		" perigyna		III
		" epigyna		IV
DICOTYLEDONES	APETALÆ	stamina epigyna		V
		" perigyna		VI
		" hypogyna		VII
	MONOPETALÆ	corolla hypogyna		VIII
		" perigyna		IX
		" epigyna	antheris connatis	X
			antheris distinctis	XI
	POLYPETALÆ	stamina epigyna		XII
		" hypogyna		XIII
		" perigyna		XIV
	DICLINES IRREGULARES			XV

M. de Jussieu has been censured, and with reason, for the arrangement of his classes, founded on the forms of the corolla. It will be seen that he censured it himself: "These classes," he says, "have the defect of not subsisting without exception." Again, he says that, "if the method be considered rigorously, and not with a view to convenience, it would be necessary to adhere, as Bernard has done, to the sole invariable characters, the *lobes of the embryo* and the *insertion of the stamens*." And yet, in proportion as the number of species has increased, it has been found that even this last character, taken from the insertion of the stamens, cannot be regarded as exempt from variation. On the other hand, everything has concurred in confirming the grand division given by the *lobes of the embryo*. Hence, the three groups founded on these lobes (the *acotyledons*, *monocotyledons*, and *dicotyledons*) are far beyond simple classes, properly so called; they correspond to the *embranchements* of the animal kingdom established by Cuvier, and ought, perhaps, to be designated by the same name. Under these three grand divisions should be placed the classes proper, each formed by the union of several families, in conformity with the judicious reflection of Mr. Robert Brown: "A methodical and at the same time natural arrangement of families is perhaps impracticable in the actual state of our knowledge;

but it would probably hasten the execution of that work were we to turn all our attention to the combination of families in classes equally natural." (*General remarks, geographical and systematical, on the botany of Terra Australis*, p. 7, 1814.) All the ranks, all the subordinations of groups, would then be marked; the entire outline of botany would be conformable to that of zoology, and great advantages would result as regards the high and philosophical views common to the two sciences. On this problem of families to be united into classes, and classes to be separated from *embranchements*, M. de Candolle expresses himself as follows: "There are but three great classes known at present," (the three which I propose to name *embranchements*.) * * "It is beyond doubt that each of these classes may one day be subdivided, so as to group among themselves the families which are alike; but this subdivision of classes, this institution of groups superior to families and inferior to classes, has not yet been accomplished in a natural manner. * * In this lies the most important problem which now presents itself for solution in the study of natural relations." (*Theorie Élémentaire de la Botanique*, 1813, p 195.)

NATURAL HISTORY OF ORGANIZED BODIES.

FROM THE COURSE OF LECTURES OF M. MAREY AT THE COLLEGE OF FRANCE.

Translated by C. A. ALEXANDER *for the Smithsonian Institution.*

I.—HISTORICAL EVOLUTION OF THE SCIENCES.

The course of instruction in the College of France is not limited to a simple exposition of the state of science at each epoch, but, as a school of discovery, extends its views to the actual tendencies of the human mind. It aims to signalize the new horizons which are opening for science, and which hold out to us the promise of further acquisitions. In order, however, to judge of the direction to be pursued, it is necessary, from time to time, to cast our glance backward, to consider the space which has been traversed, to recall the windings, the hazards, the difficulties of the route. Such a recurrence to the past is one of the most useful preparations for a new departure, and will enable us to attain our end much more promptly and certainly than it was possible for our predecessors to do. It is by availing ourselves of their experience that the march of improvement has been constantly accelerated, until, in our day, more discoveries are produced in ten years than formerly in an age.

The history of the natural sciences has, not long since, been retraced in this chair by the professor whom I have the honor of replacing. M. Flourens here passed in review the life and labors of the learned naturalists of the XVIth, XVIIth, XVIIIth, and XIXth centuries, having devoted to this subject several years of his instruction. I shall not undertake to unfold anew this historic tablet, however instructive may be its lessons. Permit me merely to retrace, with a rapid glance, the principal phases of the evolution of science. We shall thus see more clearly the tendency of scientific inquiry and the direction in which we should look for its further advancement.

The natural history of organized beings comprises zoology and botany. If we open the most ancient treatises on these subjects, we perceive that the engrossing occupation was to make an enumeration of the objects of nature. Science might be said to have been then engaged in taking possession of its domain; in making the inventory of its treasures. Each object received a name which might distinguish it, by recalling, as far as possible, its exterior characters. The "embarrassment of riches" soon gave rise to the necessity of a methodical arrangement. The first step was to separate animals from plants, and thus were formed the two great *kingdoms* of the natural world. Afterwards, in each kingdom, were created new divisions; first, *branches*, each of which was distributed into *classes*, and these again, by successive divisions, into *orders*, *families*, *tribes*, *genera*, and *species*. To be useful, these classifications should combine in the same group the beings analogous to one another, so that, by knowing to what family an animal or a plant belongs, a preliminary idea may be formed of its principal characters. It is for the attainment of this end that classifications have been so often modified, tending constantly to become more *natural*—that is to say, to

* *Revue des Cours Scientifiques de la France et de l'étranger*, March, 1867.

establish the affinity or the separation of beings on the most important characters.

Anatomy, in the mean time, came in aid and revealed the interior structure of animals and plants. It showed that certain organs seem, from their constant occurrence in the series of beings, to have on that account a predominant importance, while others which are frequently modified, and sometimes wholly wanting, appear to be but accessories, and of a secondary utility. Hence it is that the presence of a vertebral canal containing the spinal marrow has furnished the distinctive character of a whole branch of the animal kingdom, that, namely, of the *vertebrata.* In this second phase of the evolution of the natural sciences, man no longer confined himself to the rôle of a spectator of nature. He scrutinized and compared; he essayed to form an idea of the general plan of the organization of beings. The dry nomenclature had thus given place to a methodical classification.

When Cuvier appeared, comparative anatomy was doubtless already founded. Antiquity itself had learned it from Aristotle; modern times had witnessed its advancement by Cl. Perrault and Vicq d'Azyr; but much remained to be done in order to complete the classifying of animals according to their anatomical constitution. The branch of the *invertebrata* comprised a multitude of incongruous orders, among which new divisions were of course necessary. The invertebrates were divided by Cuvier into three new branches, the *Mollusks*, the *Articulata*, and the *Zoophytes.* This natural classification, based on comparative anatomy, borrowed the distinctive characters from the arrangement of the most important organs in the animal: from that of the nervous system.

It was now that, combining in a comprehensive synthesis particular facts in order to derive from them general ideas, Cuvier was enabled to throw light on some of the laws which govern the organized world. Such, for example, is the law of *subordination of organs*, which teaches us that such or such an organ, when it is present in an animal, implies the presence of other organs which are associated with it after a necessary manner. Natural history had thus become a veritable science, agreeably to the definition of Bacon: "Sciences are only facts generalized." Now, generalization had conducted Cuvier to the expression of laws. These, in turn, led him to a remarkable consequence—to the creation of paleontology. It was in conformity with his law of the correlation of forms that he reconstructed the entire skeleton of a fossil animal when possessed of but a few of its remains, and restored for science generations of beings which had long disappeared from the surface of the globe.

By the side of Cuvier another grand historical figure presents itself in Geoffroy Saint Hilaire, his cotemporary and friend, more recently his scientific adversary. Prepossessed by his labors in the natural classification of beings, Cuvier had bent his whole force to the discovery of the differences which separated them. The genius of Geoffroy disposed him rather to comparison; resemblances attracted him more strongly than differences, and enabled him to detect, in the zoological series, the unity of plan amidst the diversity of details. History will preserve the remembrance of the memorable conflicts of these illustrious adversaries, conflicts which powerfully developed two great conceptions in which, at last, there is nothing irreconcilable. From this epoch dates the rise of *anatomical philosophy.*

While zoology was establishing itself on foundations really scientific, botany had been pursuing a parallel career. As early as the XVIIth century, Pierre Magnol attempted to substitute for the ancient nomenclatures a natural classification. He sought, in 1689, to distinguish plants according to their principal organs—the roots, the stems, the flowers, the seeds. But vegetable anatomy was too little advanced to permit a classification based on the constitution of the most important organs of plants. Botany had still to pass through the artificial classifications of Tournefort and Linnæus before arriving at the more perfect

form which it received from the Jussieus. It was Antoine Laurent de Jussieu, in effect, who first clearly apprehended and distinctly defined the principle of subordination of characters. He based his classification of plants on the anatomy of the most important apparatus in the vegetable kingdom—the apparatus of reproduction. Hence the number of the lobes of the vegetable embryo, that is to say, of the *cotyledons*, the insertion of the *stamens* in the flower, became the characters on which is still based the classification of plants.

Since Cuvier and the Jussieus, zoological and botanical classifications have continued to improve; but naturalists have, on the whole, respected the plan which has been handed down to them. Rectifications have been made, and certain beings have been transferred from one family to another, with which they are more closely allied by essential characters; at other times it has been found necessary to enlarge the zoological and botanical outline for the admission of newly discovered individuals, but these partial modifications constitute but a development of the fundamental idea which has remained unchanged: the necessity, namely, of keeping constantly in view the classification of beings according to the most important characters of their organization.

Anatomy, which had produced these reforms, has itself advanced to new conquests. Up to our present century it had remained purely descriptive—that is to say, it was limited to indicating the form of the organs considered each in its own mass. Thus it determined the form of the bones, of the muscles, of the vessels, of the nerves, &c., whether in man or a lower species, or else it compared the arrangement of these organs in a succession of individuals of the zoological series. It was Bichat who impressed on anatomy a new character. He created *general anatomy*, in the sense that he studied the *tissues* which enter into the composition of the organism. The extended employment of the microscope gave a vigorous impulsion to these studies. This instrument conferred the power of discerning distinct and well-defined elements in those tissues which had till then appeared homogeneous. The globules of the blood, the animalcules of the sperm, the cellules of the epithelium, the tubes of the nerves, the acini of the glands, have been all revealed to us by the microscope. The knowledge pertaining to these subjects constitutes *histology*, henceforth inseparable from general anatomy. Transferred to the domain of comparative anatomy, histology acquires a new interest; it shows us that certain elements of the tissues undergo, like the organs themselves, very decided modifications when we follow them up in animals or plants of different families.

The microscope further conducts us to a discovery of great importance, that of the development of the germs in animals and plants. Animal *embryogeny* constitutes a new branch of science, with which are connected illustrious names, almost all being those of cotemporaries: Von Baer, Graaf, Purkinje, Coste. Nor is vegetable embryogeny less curious; the intimate phenomena of reproduction in the two kingdoms resemble one another in a striking manner. The surprised observer hesitates in pronouncing whether he has not under his eyes an animal organism, when he sees the antherozoid of certain vegetables agitated as with spontaneous motion, seeking with persistence the orifice through which it is destined to pass, or disengaging itself with apparent effort from the impediments which obstruct it. The two kingdoms thus appear to be confounded in the elements of their origin, while they deviate so widely one from the other when we contemplate them only as complete beings.

This collective view of organized nature, important as it is, still exhibits it to us only under one of its aspects. It makes us acquainted with existencies as regards their form and structure, abstraction being made of what is most essential in them; namely, life. We seem to have been traversing an immense gallery of mechanisms of greatly varied combinations, some in appearance very simple, others of an extreme complication; these of enormous mass, those of an infinite delicacy. But everything here was mysterious in its immobility; the

imagination is lost in conjectures on the function proper to each. It is now necessary to see these things in action, each executing the work for which it is adapted. The catalogue has been drawn up with sufficient exactness for present needs. To-day the current no longer tends to classification, it is directed to the study of the functions of life; that is to say, the play of the organs which anatomy has disclosed to us. This study of the phenomena which take place in living beings is ordinarily called *physiology*, or, more correctly, *biology*.

All organized beings live; animals or plants all accomplish a series of acts from their origin to their dissolution; but life is interpreted in them by manifestations as varied as their organization itself.

It may be said that biology is the offspring of anatomy, for it was from the form of the organs that man was first inspired with the comprehension of the function of each of them. This influence of anatomy gave to biology in the first instance a deductive character from which, even in our day, it finds difficulty in disengaging itself. It is true that when we see the arrangement of the articulating surfaces which unite the different parts of the skeleton, we readily comprehend the function of those organs; we see how each bone moves upon its contiguous bone, and this in itself explains the varied positions which certain portions of the body may assume. But the action of the muscles was much more difficult to be comprehended. Aristotle himself knew it not. The representative of ancient science, the founder of comparative anatomy, must have constantly observed the extreme variety of muscular development in different species of animals, and yet this anatomical principle conveyed to him no idea of the function of the muscle. It was reserved for Erasistratus, grandson of Aristotle, to discover first the elementary fact, that a muscle contracts in order to produce motion. The rôle of the other organs was still more obscure; but in regard to these, not satisfied with ignorance, inquirers accumulated in the name of science the most foolish suppositions. The viscera, in particular, were endowed with singular functions; each of them lodged one of the properties of the soul. In the head resided reason, in the heart courage and choler, in the liver concupiscence, and so with different organs. Such ideas, of course, could never have been inspired by anatomy, and they had, in effect, another source. Philosophers have by no means been insensible to the attractions of the mysterious and incomprehensible; psychology is more ancient than the sciences, and Aristotle had received from Plato a whole system ready made. It was thought indispensably necessary to lodge three souls in the human body, and each of these had several properties which could not be left without a habitat. Thus it is that mystical tradition has imposed even on those who have conscientiously sought to place themselves in direct relations with nature.

I would have willingly passed in silence these singular tendencies of the human mind to depart from the domain of real facts and to yield to the caprices of imagination; but the question relates not to a passing error to which time has already rendered justice. The ideas of Plato have a hundred times changed their form, but they have been transmitted from age to age; they prevail at this day under the form of *vitalism;* that is to say, the doctrine which pretends to have explained every phenomenon of life when it has pronounced such or such a phenomenon to be the effect of a particular *property* of the living being. This doctrine I shall not stop to combat; quite enough has been vainly said in attempting to confute those who do not choose to be convinced. It is safe to assume, however, that the vitalistic school is at present condemned for its sterility; that it loses ground every day, while the number of those is daily increasing who demand from the rigorous observation of facts and from experiment the solution of the problems of biology.

It would be more interesting to follow through its successive stages the development of the school of experimenters. To find its origin, we must go back to remote periods. Surprising it is, that the two opposite tendencies which have

so long contended for mastery come to us from the same source. Aristotle, who encumbered science with entities uselessly imagined, has bequeathed to us many exact ideas on the nature, whether voluntary or involuntary, of movement, on the development of the fœtus, &c. Erasistratus, who represented vital spirits as circulating in the arteries, recognized the true nature of the action of the muscles. Galen, so much prepossessed with humorism, with the four elements, with the forces which preside over the functions, was not the less a great experimentalist. He alone made more discoveries than all his predecessors; he showed that it is with blood that the arteries and the heart are filled; he pointed out the influence of the nerves on the movement of the muscles; he recognized the paralysis produced by a lesion of the spinal marrow. He realized, in fine, one of the most striking experiments of physiology, by showing that the section of the recurrent nerves paralyzes the larynx and extinguishes the voice.

Soon afterwards all progress is arrested before the invasion of the barbarians, and science remains torpid for 14 centuries. On its revival, the two parties reappear more opposed than ever; with an antagonism more precisely defined, and each boasting its proper representatives. While Stahl revives the *immaterial principles* of Plato, Hoffman vindicates the supremacy of physical laws in the phenomena of life. Establishing themselves on the grand discovery of Harvey, the organicians proceed to demonstrate the potency of the experimental method. Finally, Haller appears, and, reassembling the materials of physiology, makes of it a well-defined science, and impels it onward in the path of experiment.

Since this epoch discoveries have rapidly succeeded one another; with each of them the name of some experimentalist is associated: J. Hunter, Bichat, Magendie, Ch. Bell, J. Müller, savants whose work has been so ably continued by our cotemporaries. Animal physiology has reached a very advanced stage, and one of great interest. Having emerged from that unsatisfactory phase in which the sciences, while in a state of formation, are engaged in accumulating isolated facts, and too often in seeking to connect those facts by premature hypothesis, we are able not only to realize the principal conditions under which certain functions are performed, but to obtain a view of their relations and reciprocal influences. In the collective functions of the organism, we discover, in effect, a subordination such as Cuvier has pointed out in the organs themselves. The nervous system, the most constant apparatus in animals, presides over sensibility and movement, the two prominent functions in the animal economy. But it governs also the functions of organic life—respiration and circulation, which in turn react upon the nervous system, so that the knowledge of one function would not be complete if we did not know at the same time its influence upon the others.

Vegetable physiology is unfortunately much less advanced; it can scarcely be said to consist of more than certain rather vague ideas. Not only is it true that we do not at present understand the general harmony of the functions of plants; we have but a very incomplete knowledge of each of those functions in itself. The *phytologists* have attempted to model themselves upon the procedure of the zoologists, but without deriving much benefit from the imitation.

The functions of the vegetable have been classed nearly in conformity with the functions of the animal, but this assimilation may itself have operated as a shackle on the progress of the science. All that has been said of the circulation in plants was plainly suggested by ideas borrowed from the circulation in animals. The double current of liquid supposed to ascend by the tubes of the lignum and to descend again by those of the latex, would seem, according to modern authors, but a false analogy established between the physiology of animals and that of plants. Vegetable respiration is however better known. The experiments of Bonnet, Priestley, Senebier, and Th. de Saussure have established the important fact, that the green parts of vegetables exhale oxygen under the influence of solar radiation, while, in darkness, these same parts disengage carbonic acid.

As to other phenomena of vegetable physiology, they remain to a great extent unexplained. Inquiry is, in a considerable measure, still confined to the verification of facts, of which the interpretation has not yet been furnished. Such for instance is the property possessed by the root and the stalk of vegetables, the one of directing itself in accordance with the terrestrial attraction, the other of rearing itself in the inverse direction of that attraction. Ingenious experiments were instituted by J. Hunter and Knight with a view to arrive at the solution of this problem, but the results obtained by these experimentalists have proved insufficient to explain the facts. The action also which the light exerts upon plants in curving their branches, the tendency which certain plants manifest to twine themselves always in the same direction, to the right in the case of some, to the left in the case of others, are facts ascertained but not explained. In a word, vegetable physiology is a science which is in process of formation, but is far from having attained the degree of development presented at this day by animal physiology.

In this rapid review, I have attempted to indicate the principal phases of the evolution of the natural sciences; their succession must doubtless take place in an order which may be pronounced necessary, each phase preparing the way for another, and rendering possible and productive researches which would previously have been premature. At the same time, the facts would certainly be strained did we pretend to exhibit a succession of well-defined epochs, each exclusively devoted to the elaboration of one of the links of this long chain. It is not the less true however, that the human mind, in the evolution of the natural sciences, has pursued in general the course above indicated, a course which we can trace in the advancement of all the sciences which depend upon observation and experiment.

Auguste Comte, a philosopher whose doctrines have given rise, of late years, to so much discussion, has established a fact on which almost all parties are in accord. It is this: that the sciences which may be considered as having reached an advanced stage of maturity have passed through three successive phases; one *theological*, another *metaphysical*, the last *positive*. By this it is meant that man, in presence of the phenomena of nature, has been led in the first instance to suppose the influence of some divinity as the permanent cause of what he witnessed; that still later certain hidden forces or properties were imagined as governing matter in all its manifestations of activity; that subsequently, having become wise enough to resist the allurements of imagination, the authority of the ancients and the influence of routine, inquirers have taken the part of accepting nothing as true but what appeared susceptible of being demonstrated; of renouncing the search for first causes, and of directing their attention exclusively to the verification of facts and the deduction of laws under the control of experience.

I advance no pretensions to modify this formula so ingeniously propounded by Auguste Comte, still less would I venture to substitute another. But placing myself at the more restricted point of view of the sciences which have for their object the facts of nature, I think it competent still further to subdivide and specify the phases of their evolution, and to say that in all these sciences we may distinguish a certain number of periods, each corresponding to a certain stage in their development. We should thus have, first the period of nomenclature, next that of the natural classification of beings; still later the analytic study of natural characters would be developed, to be followed by the study of phenomena, leading finally to the establishment of general laws.

To show that the human mind has always proceeded by these steps, I shall not multiply examples, but will take the most general of all. I borrow it from the science which, in virtue of its comprehensiveness, takes precedence of all others, the science of the universe or cosmos, of the great *whole*.

We see the immensity of space peopled with objects each of which is an orb or heavenly body, and the first impulse of mankind was the desire to enumerate

them. Artificial groups or constellations were first established, constituting a true nomenclature of the stars. Afterwards the effort was to classify them, and the stars which appear fixed were distinguished from those which exhibit movement; among these last again, the planets, the comets, and the asteroids were to be distinguished before the immutable laws of the planetary movements could be discovered. In this classification the terrestrial globe became an individual pertaining to the *genus* planet and a member of that class called the *solar system.* It will be seen further, that the earth, considered individually, was submitted to the same analysis as the individuals which pertain to the organized world. Thus the earth has its *descriptive anatomy;* it is the physical geography which teaches us the general arrangement of the planet, its double polar oblateness, the configuration of the land and seas, the altitude of the ground and depth of the waters in different places, the course of the rivers which traverse the terrestrial surface like the veins in our organs. The earth has also its *anatomy of structure.* This is represented by geology, properly so called, which, according to the composition or arrangement of the formations, refers them to different types, as is done with regard to the living tissues. The geologist, like the anatomist, does not confine himself to the exterior appearance, but subjects each part to chemical analysis, explores the densities and cohesions, observes with the microscope the details of structure, &c. *Embryogeny* itself finds its analogue in the science which is occupied with the evolution of our globe and the genesis of the different terrestrial strata. On one part and the other, we have the same method, the same induction from what is passing under our eyes to what must have passed at an epoch inaccessible to our observation.

Thus we observe, in regard to the material study of our planet, a striking similitude between the methods employed and those to which naturalists have recourse for the study of organized beings. Without forcing the comparison, it may be carried even further. The earth has functions; there are phenomena which take place in it that bear an analogy to actual life. As the moon has been called the *cadaver of a planet,* it may be said that the earth is a living planet. Under this point of view, we shall see that it has also its *physiology.*

It is *meteorology* which reveals to us the functions of our planet. In the ingenious treatise lately published on this subject by M. Marié—Davy, there may be found a particularly vivid picture of that perpetual circulation of the waters which, quitting the sea under the form of vapor, rise into the atmosphere only to be condensed in clouds, and, falling again upon the earth, are borne by the brooks and rivers to the sea from which they were separated. The atmosphere is the seat of an analogous aerial circulation; the equatorial zone is the common goal of the lower trade-winds, as it is the point of departure of the winds of an opposite direction, the upper trade-winds, which flow thence to the polar regions, whence they will again return towards the equator. The distribution of terrestrial heat presents a perfect resemblance to that of animal heat; the same tendency on either part to the refrigeration of the points remote from the central region; the same transference of caloric by the circulation of heated liquids. Could we enter here upon the study of the distribution of the animal temperature, it would be seen that the analogies are still more striking than the present occasion permits us to demonstrate.

If I have dwelt at some length on this retrospective survey of the progress of the sciences, it is because I have thought that much instruction might be found therein for those who are seeking to advance them; and should I have succeeded in showing that the methods followed are always nearly the same, the history of the progress achieved may enlighten us as to the value of each of those methods. Thus, as I said in commencing, the experience acquired by our predecessors will serve to conduct us in the new route which we shall have to traverse. That route is plainly traced; it is easy to see that the tendency is no longer to classifications, which will, of themselves, become perfect under the influence of ulte-

rior discoveries respecting the functions of animals and plants. Nor yet is the actual tendency, as it seems, to descriptive studies. At the point which anatomy has reached, what is rather to be apprehended is confusion, through the multiplicity of minute details. Our science is already encumbered with descriptions which the life of one man would not suffice to master.

To this it may be answered that it is precisely to remedy this obstruction that recourse is had to a division of labor; that, by virtue of this expedient, we may look with confidence to the indefinite increase of human science, each ramification of which will be developed by the assiduity of inquirers devoted exclusively to some speciality. But can it be necessary to show how much such a state of things is to be deprecated? The more thoroughly any point of science is investigated the more numerous and intimate are found to be its connections with all others. Need we recall the services which zoology and botany have rendered to geology, the utility of chemistry and physics to those who cultivate anatomy or physiology? So much for the *solidarity*, the inter-dependence of the sciences, in view of the means of study and the furtherance of one through the other; a like solidarity is found in regard to the laws which govern them.

Every law, when once known, throws light on a vast field, for it controls a great number of phenomena. The law of *proportionality to the squares* applies not only to the gravitation of the heavenly bodies, but to light, electricity, magnetic attraction, accelerated movement, &c. Chemical laws enable us to foresee a great number of phenomena which no one has yet attempted to realize.

If all the sciences allowed of our evolving, from this time forward, precise laws, it would be easy for us to combine in a grand assemblage all dispersed facts; a single mind might embrace in their generality all human cognitions; what the sages of antiquity could not realize by reason of the narrow extent of their knowledge, would be accomplished to-day on a field much more vast, thanks to the excellence and simplicity of method. This ideal, which however we shall never attain, should at least be the star which serves us for a guide; it is to the research of the laws of life that it behooves us henceforth to direct our earnest attention.

II.—Office of Analysis in the Sciences.—Power which it Derives from the Employment of Greatly Improved Instruments.

I have endeavored to show that the human mind proceeds in all the sciences after nearly the same manner, so that, as regards each of them, progress is represented by an evolution strikingly similar. I hope to prove also that the sciences, in the process of their development, tend to an approximation towards one another, resulting in their reciprocal advancement, since each of them sheds light upon the other. Zoology and botany, it is obvious, have furnished to geology an inestimable element of progress, by disclosing one of the most indispensable characters for recognizing the relative age of different formations. This character is derived from the determination of fossil species, some of which characterize, so to speak, certain geological epochs.

Physics and chemistry have so many points of contact that it is almost superfluous to mention them; the time may be foreseen when these two sciences can be no longer separated, chemistry constituting, in effect, only molecular physics. But physics and chemistry exert on the other hand an ever-increasing influence on the natural sciences. Neither animal nor vegetable physiology can dispense with their aid; it may even be said that all that we know accurately in these two sciences is what is explained by means of the laws of physics and chemistry. Examples would present themselves in crowds were it requisite to furnish them. Thus the mechanical phenomena of respiration were unintelligible before atmospheric pressure had been discovered. Anatomists and physiologists were surprised to see the air rush into the pleura when

the diaphragm or walls of the breast of an animal, alive or dead, were pierced; there is now nothing obscure in the nature of this effect. The same cause explains also many phenomena relating to the exchange incessantly produced between the gases of the blood and the atmospheric air, the action of respiration on the course of the blood, &c. Mechanics elucidates the muscular phenomena, and in general all the movements produced by animals. The circulation of the blood borrows from hydrodynamics the explanation of everything relating to the movement of the sanguineous fluid. Without chemistry, what ideas could we possess respecting the digestive functions, the offices of respiration, the function of the glands? Optics and acoustics are treated, in the works on physiology, in the same manner as in those on physics. Finally, the laws of electricity acquire every day more importance in the interpretation of the nervous phenomena.

All this proves the reciprocal dependence (*solidarity*) of the sciences; it shows that it is necessary to separate them as little as possible, that the tendency should be to their simplification, to the reduction into general laws in order to render them easily accessible to every one.

A very important point, for it is decisive of success or failure in scientific researches, is the choice of a good method. On this subject it is necessary to be guarded against a very common error. We become habituated generally by the usual processes of demonstration to pass from the simple to the composite, to start from a well established principle in order to arrive, from one deduction to another, at the demonstration of more complex propositions. It is in this way that the theorems of geometry are successfully demonstrated; but is it by this method that a science is established? Far otherwise; nor do those who make discoveries in the natural sciences proceed in this manner. They observe a great number of facts, compare them, place them side by side, seek the conditions which modify each phenomenon, and succeed only in the last place in finding a principle or a law which may guide the understanding in the midst of an embarrassing complexity.

Medicine, a science which touches us so nearly, since it deals with the troubles which occur in the functions of life, was long misled by that false method which generates *systems*. Starting from a principle supposed to be true, it proceeded with the most irreproachable logic to heap deductions upon deductions, till the moment when error became so obvious that the whole fabric collapsed at once, and the work was to be commenced anew. It was a pure metaphor that wrought the evil: "It was proposed to *construct* the science, and a corner-stone was to be sought to support the edifice." But by what right, among so many materials, was one stone to be taken for this purpose sooner than another? By what token was it to be recognized as the real base of the structure? Certainly, by none. If there must be a metaphor, I would prefer to compare the study of the natural sciences to the labor of the archeologists in deciphering inscriptions traced in an unknown language. They try, turn by turn, several senses for each sign; they seek assistance at the same time from the conditions under which each inscription has been found, and from the analogy it presents with inscriptions already known, and they arrive only in the last place at a knowledge of the principles by which they teach others to decipher the strange language.

In every science progress is only to be obtained by the employment of certain processes which act like powerful levers in the service of the human mind: *analysis*, which serves for research, and *synthesis*, which is employed to verify the results of analysis, or to set in a more simple light a truth already discovered. But everything is susceptible of improvement, even the means which are at our disposal for the realization of further progress. I propose, therefore, summarily to state the present resources of analysis and synthesis, instruments which are so constantly to be handled by the teachers as well as cultivators of science.

Analysis consists in reducing to its most simple elements a phenomenon too

complex to be otherwise comprehended. If the multiplicity of simultaneous incidents perplexes our understanding, we endeavor to abstract one of these incidents, observe it as exactly as possible, then, passing to another, study it in the same manner. In thus overcoming successively the difficulties which present themselves, and which in combination exceed our efforts at comprehension, consists the function of analysis, and it is this which constitutes the source of its power.

But, in this conflict of details, difficulties of another order still present themselves. These arise from the insufficiency of our senses, baffled alike by objects too small or too large, too near or too remote, as well as by movements too slow or too rapid. Man has found the means of creating for himself more powerful senses in order to detect the truth which evades him. He has rendered his vision more penetrating by help of the telescope which sounds the immensity of space, and of the microscope which explores the infinitely little. Balance and compass in hand, he estimates with precision the weight and volume of bodies, which his touch indicated to him in only a rough manner. The more advanced the state of any science, the more it has need of instruments, for it has passed beyond the horizon embraced by the unassisted view of our predecessors. It has transcended the limits of the circle in which the human intellect was so long exercised, while exhausting itself in contemplating the surface of the same objects and consuming in sterile dialectics the power which to-day it employs in rigorous observation.

Instruments are the indispensable intermediaries between mind and matter; the physicist, the chemist, the astronomer can effect but little without their succor; the anatomist, the physiologist, the physician have recourse to them as indispensable to the progress of medical science. The invention of cadaveric injections and that of the microscope have inaugurated a new era for anatomy, which owes to the use of these expedients the comparative perfection which it has attained in our day. The same is the case with physiology; it is to the manometer, the thermometer, to electric machines of various construction, apparatus for registering, &c., that the physiologist is indebted for the power of substituting experimentation, in its proper sense, for observation, always slower and often powerless to discover the laws which govern life.

To show the progress already realized in the method of analysis, and to mark the multiplicity of resources of which it may avail itself, we take a few examples:

In chemistry, when the object is to recognize the nature of certain bodies which enter into a combination or mixture, we proceed, by *qualitative* analysis, to disengage each of these bodies and to isolate them successively. Then, by *quantitative* analysis, we determine in what quantity each substance existed in the mixture. In making this discrimination, the balance is at our service. This, we see, is an apparatus borrowed from physics which enables the chemist to arrive at exact determinations. But the helpful intervention of physics stops not there. In virtue of that solidarity of the sciences, of which I have before spoken, the chemist resorts to the physicist for the aid of still other instruments. If, for instance, we have the solution of a known salt whose degree of concentration we would ascertain, there is no need to destroy the mixture and extract the salt, in order afterwards to weigh it; we seek, by means of the *areometer*, the density of the mixture, and, knowing the density proper to the salt, it is easy to calculate the quantity contained in the solution. If in another solution substances exist which are crystallizable together with others which are not so, the use of the *dialyser* enables us to effect their separation. This again is an apparatus of physics placed at the service of chemistry. The *polarimeter* is also of great utility. It enables us to appreciate in an instant the existence of certain substances contained in a solution, and to determine their proportion with rigorous exactness. Lastly, the *spectroscope* contributes a new power to

chemistry: it has extended the domain of chemical analysis beyond the world we inhabit, by enabling us, from the optical properties of the light of the stars, to determine their chemical composition, and to affirm, for example, that in the sun there must be iron, nitrogen, cobalt, &c.; in the star Aldebaran, sodium, magnesium, calcium, iron, mercury, hydrogen, &c. Thus science, by means of analysis, has realized wonders which the most daring imagination would have never ventured to conceive.

In physics, the functions of analysis are not less extensive. It is by employing different kinds of apparatus, each of which reveals certain properties of electricity, light, heat, &c., that we have succeeded in forming an idea of the manner in which these agents act in nature. The physicist renounces the idea of ascertaining their essence as we renounce a knowledge of the essence of life, and is content to describe each agent according to its manifestations. Electricity, which reveals itself to us in great meteorological effects, in the production of lightning and boreal auroras, for instance, everywhere else evades our perception, and yet it is demonstrable that everywhere in nature electricity exists. The *electroscope* discloses it in the atmosphere which surrounds us. The *galvanometer* shows us that electric currents are formed, so to say, wherever an act of a physical nature is accomplished: water which evaporates, a plant which vegetates, an animal which lives, give rise to electric phenomena which our senses cannot directly perceive, but which we render perceptible by means of instruments of analysis. Such expressions as *electric currents*, *electro-motive forces*, *intensity* and *tension* of electricity, are artifices of language which enable us to conceive more readily the conditions under which the phenomena called electrical are produced and modified. But in proportion as known facts become multiplied by analytic researches, science is seen to disengage itself from the ambiguities of language and to sacrifice the expressions which are no longer useful to it. It is thus that the hypothesis of two electric fluids, the one *positive*, the other *negative*, is tending at present to disappear.

What we know regarding *light* has been acquired by the same method: we have learned to decompose it by the *prism* into its different elements; some colored in different manners, others invisible, but endued with heat or chemical properties. The theory of light furnishes us with a good example of the disappearance of an hypothesis in the presence of contradictory facts. We know that the hypothesis of radiation has vanished before the phenomenon of interferences, and has given place to the theory of undulations, which alone explains all the phenomena actually known.

Thus physical agents become characterized every day in a more complete manner, and are more and more accurately determined by the characters which their analysis discloses. I shall not attempt to follow the progress realized by the analytic method in the knowledge of magnetism, heat, mechanical force, &c. I confine myself to the statement already made that the solidarity of the sciences constantly augments in proportion to the progress realized. For the different branches of physics the fusion is evidently taking place in our own day. It is interpreted to us by the profound conception of the *equivalence of forces* and of the transformation of mechanical labor into heat or into electricity.

The naturalist who is not content with observing the forms, however varied, of organization in animals and plants, must proceed like the physicist and chemist, if he desires to discover the conditions of life. His first means for the analysis of phenomena is *vivisection.* It is through this that he becomes a witness of the accomplishment of functions; all that is visible and palpable in the play of the organs is revealed to him by this *anatomia animata*, as it was called by Haller. On this head I could say nothing which will not be found more competently stated in the valuable treatise of M. Cl. Bernard *(Introduction à la Médicine expérimentale.)* In this work may be seen everything relative to phy-

siological experiment, while excellent advice is given regarding the disposition of mind which it is necessary to bring to the study of biology.

But, of itself alone, vivisection is insufficient for this pursuit; it can do no more, so to say, than lay bare the phenomenon simultaneously with the organ which is the seat of it; it reveals to our senses only what they are capable of perceiving. Now, we have seen that in physics our senses teach us very little, and that it is necessary, at every step, to have recourse to apparatus for analyzing the more delicate phenomena. The same is the case in biology. The electrical phenomena which take place in animals are, in certain cases, directly perceptible. The commotion produced by the torpedo and gymnotus have been known from antiquity, but the most sensitive galvanometers have been needed to detect those electric modifications, so weak and yet so important, which accompany the nervous and muscular actions. Du Bois-Reymond and his successors have made known to us an entire new phase of physiology, and one of the most interesting kind. Optical apparatus is indispensable for the exploration of the interior of the eye, as well as for the delicate measurement of the curvatures of each of the refractive mediums which compose it. Thus, while dissection teaches us certain details of the organization, it would nevertheless deceive us by destroying the normal disposition of the parts, had we not the means of studying the living apparatus *in situ*.

Anatomy shows us the organs with a definite form and volume; physiology, on the contrary, teaches us that most of the organs present, in the actions of life, changes both of form and volume, a few of which only can be easily perceived. We must resort to instrumental aid for the demonstration of changes too delicate for naked vision. Now, *micrometry*, as is well known, has attained an extraordinary precision in the determination of the diameters of objects extremely minute; it constitutes one of the principal resources at the disposal of histology, and enables it, in effect, to assign to each element its normal diameter, which is one of its important characteristics.

As there exists, then, a micrometry by which we can measure the slightest changes in the volume of the organs in living animals, I deem it the more important to indicate the apparatus destined for this purpose, since it is still but little employed, though possessing, in certain cases, very great utility. It will be remembered that discussions were heretofore maintained respecting the dilatation of the arteries under the afflux of the blood propelled into them by the contraction of the ventricle. Some writers contended that the arterial system makes room for the sanguineous wave by means of an elongation sustained by the vessels, while others thought that the arteries, in this act, dilate and lengthen at the same time.

To resolve this question, M. Flourens conceived the idea of encircling the artery of a living animal with an interrupted ring formed of an elastic spring, which would yield to the dilatation of the artery and manifest it by the separation of the two ends of the ring. This separation takes place, in effect, whenever a new discharge of blood is received from the heart. But the method is not wholly free from objection. If we suppose the pressure of the elastic ring to produce a slight constriction of the vessel, the latter may simply recover its normal dimension, and in this way, without undergoing dilatation, would separate the ends of the ring which compressed it. M. Poiseuille employed a more rigorous method, which consists in placing the artery which we propose to examine in a small box with rigid walls, pierced on one side and the other by a suitable hole. In this box the artery is maintained at such a degree of tension as to preclude any liability to elongation through pressure of the blood. The box is filled with liquid, and is furnished at some point in its walls with a capillary tube in which the liquid ascends to a determinate level. If the blood-vessel thus enclosed undergoes the slightest augmentation of diameter, it necessarily displaces the liquid of the box, and the level in the capillary tube is seen to rise or descend,

according as the diameter of the vessel is increased or diminished. This method is susceptible of a great number of applications; it enables us to show that all the vascular organs undergo, at each sanguineous discharge from the heart, a distension followed by contraction, similar to that presented, in a higher degree, by the erectile tissues. But this mode of examination is not new; there may be seen in the works of Swammerdam the description of an apparatus very analogous to the one in question, and destined to determine whether a muscle in contracting undergoes a change of volume.

Of all the phenomena which characterize life, movement is the most important; it may be said, indeed, that in general it is movement which gives their distinctive character to all the functions; now, it is under this aspect that the phenomena of animal life can be analyzed at present with the most admirable precision in the three correlative elements of *duration*, *extent*, and *force*. We are but little capable of appreciating duration with exactness, especially that which is very short, and we generally consider as instantaneous such phenomena as occupy a space of time shorter than the half or quarter of a second. For the same reason we assume the synchronism of two acts which follow one another at a short interval. But *chronometry* has made so much progress of late that we can now measure the shortest durations, thanks to the apparatus employed by the physicists. The velocity of projectiles, of light, of electricity, is readily reduced to measurement, and nothing prevents the application in general of the same methods to the still shorter durations of physiological acts. The *extent* of a movement is susceptible of very exact appreciation, provided the movement furnishes a trace which may be afterwards submitted to the estimates of micrometry. The idea of *force* has recently undergone an important modification; it has been reduced to that of *labor accomplished*, and is referable henceforth to a determinate standard, the *kilogrammetre* and its divisions. We find ourselves therefore in possession of accurate terms of comparison, and should eliminate in future every vague expression relative to movement. We should characterize it in every case according to its duration referred to the second of time, its extent in terms of the metre or its fraction, its force as expressed in kilogrammetres. Perhaps a still more complete conception is that which further characterizes a movement by its *form;* that is to say, which takes account of the different phases of the movement, and no longer only of its commencement and end, its maximum and minimum, but which determines all the intermediate states. Such is the result obtained by the *graphic method*, to which I shall have occasion elsewhere to call attention, as furnishing of itself the solution of a great number of problems of the highest importance.

Movement, before being executed, is, so to say, potentially contained in certain causes which produce it: *weight*, *elasticity*, the *pressure* of a liquid, the *tension* of a gas. We now know how to appreciate these forces, which may be called virtual. It is *statics* which measures them, and introduces into their measurement that rigorous exactness which tends at present to become general. The application of the *manometer* to the valuation of the pressure of the blood, of the thoracic aspiration, of the force with which the glandular reservoirs contract, is a further step in the progress of our epoch.

If I have here given but a rapid and incomplete enumeration of all these exact processes and their appropriate apparatus, it is because the occasion will hereafter present itself, in my collegiate course, of describing them more completely, and of more fully exemplifying their value. I have aimed to show in the first place the resources which we have at our disposal, and to prove especially that it is by drawing more closely its relations with the other sciences, that biology has become progressive and will continue to progress. Now that we are provided with new means for attempting the solution of the problems of life, we may resume the researches in which our predecessors have been foiled. A subject which might be supposed to be exhausted becomes once more a fertile

field for study, if we acquire new processes with which to explore it. It is chiefly when we recur to ancient experiments that we are struck with the progress which has been realized. We might almost be disposed to condemn the narrowness of view of the old experimenters, if we did not revert in thought to the epoch when they lived, and to the exiguity of the means of analysis of which they could avail themselves.

Still another reason necessitates the employment of apparatus in physiology. Even in the cases in which vivisection reveals to us important facts, it induces such extreme perturbations in the functions of life as greatly to modify them and to convey a false idea, if the normal expression of the function be assumed to be exhibited in any phenomenon which we may thus witness. To take an example, the case may be cited when the section of the spinal marrow is performed on an animal, and artificial respiration is practiced in order to maintain organic life as long as possible. Under these conditions the phenomena of circulation undergo so profound a modification that we should be on our guard against the false ideas which may be drawn from the experiment. The rapidity of the current of the blood becomes excessive, the pulsations of the heart are accelerated, the central temperature is lowered, while the peripheral temperature rises. The physiologist should, therefore, endeavor to inflict on the animal which he is examining as little mutilation as possible, if he would obtain an exact idea of the normal conditions of the circulation of the blood and the animal temperature. We know, moreover, that the secretion of the glands, under normal conditions, differs much from that which we collect by artificial means. Thus the pancreatic juice derived from an animal in which an opening has been effected differs chemically from that which the gland discharges normally into the duodenum. It would not be difficult to multiply examples showing how necessary it is to leave the animal in its normal condition if we would not have the function interfered with; but this is only attainable by means of the different and delicate apparatus of which some portions are above enumerated.

Another cause often obliges us to renounce vivisection, and to substitute the use of apparatus: it is the necessity of directly studying the human physiology. Of all the beings whose organization and functions science has essayed to investigate, man has been the most frequent object of study. It is the human physiology which serves, so to speak, as a type for that of the whole animal kingdom.

Nevertheless, if it is true that our own organism and functions seem to present the most complete model of animal organization, it is not less true that certain organs, as well as certain functions, are, in us, less sharply characterized than in the lower order of beings. Hence it is of the greatest importance to follow, by analysis, each of the phenomena of life in the whole series of living beings, or at least in the principal types, with a view to ascertaining what are the different processes which nature employs in order to arrive at her end, the life of the individual and of the species. Hence the origin and object of *comparative physiology.*

It is to the human being, however, his organs and his functions, that the greater number of investigations is at the present day directed. And, as all resources are to be laid under contribution in the prosecution of our object, we may sometimes borrow aid from the science of *medicine*, which finds in the study of maladies certain conditions not always to be realized by experiment. It is not to be forgotten, however, that medicine is not the basis of biology, though, in an utilitarian point of view, it may be its end. In such inquiries as we are now pursuing, it is but one means the more of analyzing the conditions which modify the functions of life, and of arriving at a better determination of the laws which regulate those functions. In order to give an idea of the influence which medicine has had on the knowledge of the organism, I need but recall that it was in a case where a perforation of the thoracic walls had

occurred that Harvey observed the beatings of the heart; and in another, where a gastric fistula had been formed, that Beaumont conducted his memorable studies on digestion. The vices of congenital conformation furnish us with numerous indications, not only on the subject of *embryogeny*, but also in relation to certain functions, such as those of the nervous system, respiration, and circulation, which produce the movements of the cephalorachidian liquid, &c.

The above is but a summary statement of the means of analysis at our disposal at the present time. Our resources, it will be seen, are great, and furnish a guarantee of success in researches yet to be undertaken. I would repeat, in conclusion, what I have before said, that progress is visibly taking place through the fusion of the sciences, and for us, naturalists and biologists, resolves itself into the facilities which we every day derive from physics and chemistry. The time will come, no doubt, when we shall be able in our turn to furnish to those sciences new elements of progress. But, for the moment, we are their debtors, for the reason that the physical and chemical sciences, more simple than ours, and long disengaged from the bad methods by which we have been misled, are to-day more advanced than biology, in the sense that they arrive more readily at exact ideas of the phenomena which they study. It is only after having fruitlessly employed in the study of the phenomena of life the methods supplied by physics and chemistry that we shall have any right to invoke the intervention of extra-physical causes for the explanation of the vital phenomena; and it is not difficult to see how far we are from having exhausted the resources which physical and chemical analysis now places at our disposal.

III.—Experimental synthesis in the natural sciences.

In speaking of the processes which the human mind employs in scientific researches, I have mentioned analysis and synthesis. We have thus far treated of analysis; we have considered it in its progressive improvements, and know, in a general manner, the immense resources which it has at its command.

It remains to inquire the meaning of synthesis and the services which it is capable of rendering. It has already been seen that it is not a method of research; that a science which should propose to found itself upon synthesis, by setting out upon principles established *à priori*, would incur the peril of going widely astray. But nothing of this sort is to be apprehended when analysis has finished its work and has put us in possession of a large number of facts, well established. It is then that the office of synthesis commences. *Synthesis* is the opposite of analysis; it reconstructs what has been decomposed. This is the most general definition of the method. But to give a more complete idea of it, it is well to follow it in its different applications. We will first examine experimental synthesis, in so far as it serves to control the results of analysis by reproducing a phenomenon through a reassemblage of the conditions of its existence. Afterwards we shall pass to synthesis properly so called, being such as it is defined by *scholastics*, and which collects particular facts into general laws.

Experimental synthesis recompounds that which has been decomposed into its different elements. The chemist, for instance, when he has decomposed water by means of analysis and has separated it into oxygen and hydrogen, can recombine those two gases. He has effected the synthesis of water. In this second experiment, then, is found the most satisfactory demonstration of the exactness of the first. Synthesis has served for the proof of analysis.

In organic chemistry the introduction of synthesis is altogether recent, but it has effected in this branch of science a real revolution. In the last century, chemists believed that organic matter was formed in animals and plants by virtue of forces different from those which govern unorganized matter. Buffon even recognized an animated organic matter, destined to furnish unceasingly the material of beings endowed with organization. As late as 1849, Berzelius still admitted of special chemical laws in organized nature.

It belonged to Berthelot to overthrow these erroneous opinions, and to show that the same laws prevail in organic chemistry and mineral chemistry; to prove that by employing the inorganic elements disclosed by analysis, it is practicable to reproduce by synthesis a great number of the substances found in vegetables. It was thus that, by means of carbon and hydrogen, our learned chemist formed acetylene, C^4H^2; this body, treated with nascent hydrogen, gave him olefiant gas, C^4H^4.

By the employment of water and carbonic acid, Berthelot formed the oxide of carbon, C^2O^2. This again, by the fixation of the elements of the water, yielded formic acid, $C^2H^2O^4$, whence was obtained the gas of the marshes, C^2H^4. From the gas of the marshes, in turn, are derived, by successive condensation of the elements, acetylene, propylene, benzine, and naphtaline. The ternary bodies spring from the preceding by the addition of oxygen. Thus are produced the alcohols: the methylic alcohol, $C^2H^4O^2$, by the oxydation of the gas of the marshes; common alcohol, $C^4H^6O^2$, by the hydratation of the olefiant gas. By removing the hydrogen from the alcohols, we obtain the aldehydes; by oxydizing the alcohols, we form the organic acids. By the fixation of the nitrogen in these new products, whether by means of ammonia or by the action of nitrous acid, we obtain the quaternary compounds. So that it may be foreseen that a resort to synthesis will enable us to reproduce artificially those important substances which are called the alcaloids of vegetables.

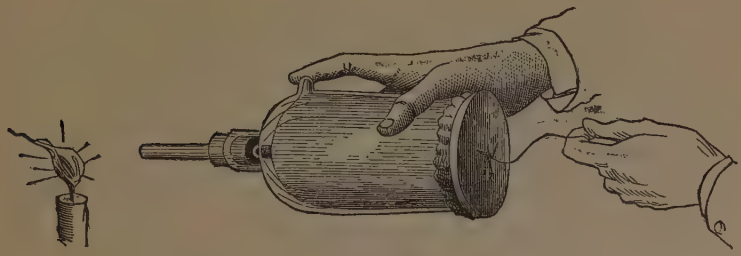
The physicist also makes extensive use of synthesis. Thus, when he wishes to produce with great intensity a phenomenon of which analysis has revealed to him the conditions of existence, he constructs an apparatus in which he assembles those conditions, and evokes the phenomenon with a degree of evidence which leaves no longer any doubt. Knowing, for instance, the electric phenomena which occur between two different metals, both submitted to a chemical action, physicists have constructed batteries which produce currents of dynamic electricity of a surprising intensity. In general, what is called an instrument of demonstration is constructed in virtue of a synthetic idea.

In biology, synthesis is generally too little employed, and yet it would appear, in certain cases, eminently useful, whether for controlling the results obtained by analysis or for furnishing a clear and striking demonstration of the phenomena. This means of control and demonstration should certainly not be neglected. It is often proper that experiments should be made with the view of reproducing a phenomenon, and demonstrating that it takes place in certain determined conditions. In this case, the experimentation is synthetic. One of the principal applications of this method consists in reproducing, outside of the living being, certain phenomena which take place in the interior of the organism. Thus, in order to demonstrate the action which the air exerts on the blood through the walls of the pulmonary cellules, we make it appear that venous blood can be arterialized by the action of the air taking effect through an organic membrane. To prove the action of the acids of the stomach as well as that of heat in digestion, it is usual to show that, in a matras, the addition of an acid to a mixture of gastric juice and food excites an artificial digestion which would take place but very incompletely without the presence of the acid. The action of heat in digestion may at the same time be shown, for the temperature must be somewhat elevated for that phenomenon to be produced with rapidity.

The physical phenomena which occur in living beings are particularly susceptible of synthetic demonstration. The apparatus of demonstration or *schemas* are admirably adapted to give an idea of the mechanism of these functions; nor can anything more instructive be readily imagined than the employment of such expedients, which enable us to assist, as it were, in the production of all the details of the phenomena.

There are many, doubtless, who will recall the difficulties experienced, at the outset of physiological studies, in comprehending perfectly the mechanism of

respiration; that *virtual* vacuum, as it is called, which exists in the cavity of the pleura, and into which the air tends to precipitate itself as soon as an opening is formed at any point of the thoracic structure. Now, this phenomenon can be counterfeited in a very simple manner. (*Fig.* 1.)



We take a bottle whose bottom has been removed and is replaced by a stretched membrane of caoutchouc: this bottle will represent the thoracic cavity, while the membrane corresponds to the diaphragm. In the interior of this apparatus we place an elastic bladder of caoutchouc, which represents the lungs. The neck of the bladder is luted to the neck of the bottle, so that there shall be but one orifice, that which enables the exterior air to communicate with the interior of the bladder of caoutchouc. A hole has been formed in one side of the wall of the bottle, and a cord is attached to the centre of the membrane which represents the diaphragm, for the purpose of communicating to this membrane movements which imitate the diaphragmatic action in respiration. We now proceed to place this apparatus in the same conditions with the thoracic cavity. We blow through the throat of the bottle into the bladder, so as to distend it until it fills the cavity of the bottle and expels the air contained therein. We have thus established a state of things analogous to that in which the thorax is filled by the expanded lungs. If we cease to blow, leaving the lateral hole free, the wind at once enters with a whistling sound through the hole in question, precisely as happens in the case of an animal whose breast has been suddenly pierced. But, if we close that hole after having finished the insufflation, the bladder will continue adhering to the walls of the bottle, although the throat of the latter be open. To imitate the movements of the diaphragm, we exert a traction on the membrane; the bladder follows all these movements just as the lungs would do, and a reciprocating motion is established between the exterior and interior air, through the throat of the bottle. If we desire to measure the energy with which the bladder-lung tends to collapse upon itself, a manometer is fitted to the hole in the side-wall; the mercury will now be seen to be drawn towards the apparatus with a force represented by the inspiration of a column of air a certain number of centimetres in height.

A rather curious phenomenon sometimes occurs in surgery, being a hernia of the lung through a wound of the breast. This hernia might seem inexplicable, in view of the tendency of the lung in such case to collapse upon itself. If we close the throat of our bottle, an act which corresponds to the occlusion of the glottis in an animal and prevents the escape of the air from the breast, the bladder will no longer have, as before, a strong tendency to retreat upon itself; for, to do that, it must become empty. At this juncture let the diaphragm be stretched, which will be equivalent to a strong effort at inhalation. The bladder will then be seen to form a hernia through the opening in the side of the bottle. The explanation of this fact is quite obvious: the air, compressed in the

elastic pouch with a certain force, tends to escape outwards by driving back the thin membrane which confines it; this it effects at the sole point where the walls offer little resistance. Suppose, for an instant, that, in place of the thin membrane which now forms the hernia, there were a spongy but more consistent tissue, like that of the lungs; the hernia would become strangulated between the edges of the opening and be unable to re-enter spontaneously, even when the effort has ceased. Many other demonstrations might be made by means of this simple apparatus.

Without digressing from the subject, another fact may be noticed which long seemed obscure, but which is susceptible of a synthetic demonstration at once simple and convincing. Have the intercostal muscles any action on the movement of the ribs, and, if so, what is that action? This was the subject of much discussion among the physiologists of the last century.

The solution of the question was demanded of experiment, and it was found that, in living animals, the external intercostal muscles contract at every inspiration of air. But this result of observation presented something paradoxical and inexplicable. The external intercostals are extended between two ribs: it would seem, therefore, that they ought, in contracting, to bring the ribs nearer to one another. Now, at the moment of inhalation, the ribs separate and the intercostal spaces are enlarged.

P. Berard, in his courses of physiology at the Faculty of Medicine, was accustomed to recall the discussions in question, and removed any hesitation on the part of his auditory by tracing on a tablet a schematic figure which rendered the phenomenon easily intelligible. He would state, at the same time, that he had received from Dr. Hutchinson a small apparatus formed of pieces of wood in imitation of the arrangement of the ribs in relation to the vertebral column, and of elastic bandelets which represented the action of the external intercostal muscles. The whole, when the parts representing ribs were lowered so as to exert a traction upon the elastic bandelets, was calculated to take the position attending the act of inhalation in the animal frame. Annexed is an apparatus which I have constructed upon these indications and which aptly reproduces the phenomenon in question, (*Fig.* 2.)

The vertebral column is represented by a piece of vertical wood on which three transverse pieces are articulated: these represent the ribs. The direction of the intercostal muscles is indicated by that of the braces of caoutchouc fastened by pins on the cross-bars of wood. When the ribs are horizontal, as in the figure, there is a considerable interval between them, but the insertions, A, B, of the brace of caoutchouc are not so widely separated as in the case when the rib-pieces, being lowered, approach and touch one another. In that case, the brace of caoutchouc corresponds to the diagonal of a very oblique parallelogram. Now, the position of the elastic brace is that which the external intercostals present in relation to the ribs. The contraction of these muscles serves, therefore, to raise the ribs, as the elasticity of the caoutchouc acts in the schema which we have been describing.

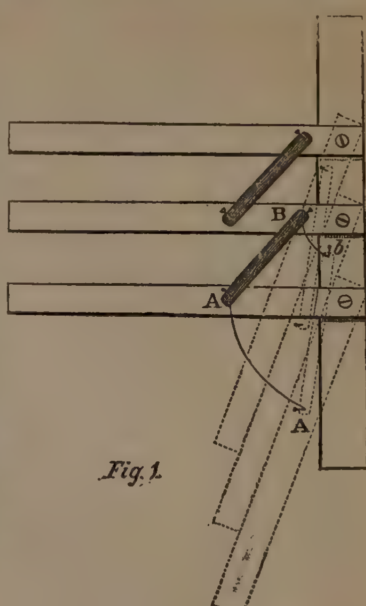


Fig. 1.

Among the mechanical phenomena of the circulation of the blood there are quite a number which may be imitated in a perfect manner. A schema, well known in Germany, is that of Weber: it shows how the circular movement of the blood is accomplished in that vast self-re-entering system represented by the heart and blood-vessels, (*fig.* 3.)

We take an elastic tube, curved upon itself, so as to form a complete circuit, which may be filled with a liquid by means of the funnel, *e*. At a point in this tube a part, marked *c*, is bounded by two valves, both of which open in the same direction. This portion of the circuit corresponds to the heart. At the point directly opposite the portion *c* is placed, at *c*, a tube of glass, in which a sponge is infixed tightly, forming, of course, an obstacle to the passage of the liquid, in regard to which it exerts a resistance like that opposed by the capillary vessels to the course of the blood. The apparatus being now filled with liquid is ready for operating. If intermitting pressures be exerted on the part *c* which represents the heart, the enclosed liquid is propelled and made to pass into the portion of the tube where the play of the valves permits its being introduced, namely, into *a*, *a′*. Under the influence of compressions frequently repeated, the portion into which the liquid flows becomes distended. Now, it is in this condition that the arterial system subsists in animals, since there the blood is continually pressed forward by the systolés of the left heart. Hence the liquid acquires in this part of the tube a considerable amount of pressure which imitates, with sufficient exactness, the pressure of the blood in the arteries. The sponge, *c*, allows the liquid to pass gradually from the arterial part of the tube into the venous part, that is to say, into the portion *v′ v* of the apparatus. This passage of the liquid takes place in a continuous manner, notwithstanding the intermission of the impulses given to the liquid. Here, then, we realize an imitation of the phenomenon produced in the circulatory apparatus: the regularity, namely, of the course of the blood in the small vessels. In both cases this result is obtained through the effect of the elasticity of the conduits in which the liquid has circulated. Further, it is the same cause which produces in fire-engines the regularity of the jet, notwithstanding the successive checks in the play of the pump. In apparatus of the latter kind resort is had to a bell-shaped receiver, under which the liquid arrives on issuing from the pump, and which counteracts the irregularities of the motive force.

It should likewise be remarked, that, under the influence of successive impulsions given to the liquid by pressing on the part *c*, it will be found that the arterial and the venous portion of the circuit present opposite conditions of repletion: the arterial pressure constantly tending to distention at the expense of the venous portion which is at the same time partially depleted. It is thus also in the economy of the living animal, the repletion of the arterial system taking place at the expense of the contents of the veins. Finally, it will be observed that each impulsion given to the liquid, by the compression of the tube at *c*, communicates to the whole of the arterial column a pulsation analogous to that presented by the arteries of a living animal, and that this impulsion is annulled at the extremity of the arterial part, so as to fail entirely in the venous portion. On the whole, then, this schema of Weber's reproduces in a very sim-

ple way some of the principal phenomena of the circulation of the blood: 1st. The circuit and the continuous current through the whole system of tubes; with the understanding, however, that the apparatus is intended to represent only one of the two circuits which constitute the circulation in the higher animals—namely, the greater one. 2d. The formation of two unequal pressures, one rather high, being that of the blood in the arteries; the other lower, being the venous pressure. 3d. The continuity of the course of the blood in the capillary vessels under the influence of the elasticity of the arteries. 4th. The pulsation which is produced in all the arteries at each systolé of the heart. It might be possible to imitate in a more perfect manner the hydraulic phenomena of the course of the blood, but the schema before us suffices for the moment as exhibiting a synthetic reproduction of an action taking place in living beings.

In studying the circulation, theoretical considerations had led me to conclude that the elasticity of the arteries produces on the course of the blood still other effects than those demonstrable by the apparatus of Weber, and that this elasticity itself favors the circulation by diminishing the obstacle which the heart encounters at each contraction; in other words, that the heart has less difficulty in emptying itself into elastic vessels than it would meet with if the arterial system were formed of rigid conduits. Now this effect of the arterial elasticity has been contested by the whole body of physiologists. Some of them have held, with Bichat, that the circulation would be effected quite as well in inert tubes as in elastic ones, the only difference being that in inert vessels no pulsation would be felt. Others, relying on experiment, asserted that two tubes, one elastic, the other inert, give passage to the same quantity of liquid if both have the same calibre; and this is perfectly true if the flow of the liquid takes place under a constant discharge, but ceases to be true if the afflux of the liquid occurs in an intermittent manner, as is the case with the circulation of the blood. Still other physiologists, struck with the regularity of the course of the blood in the small vessels, have considered the elasticity of the arteries as an additional force, which propels the blood in the arteries during the repose of the heart. But these also were in error, and we might refute their opinion by saying, with Berard, that the elastic force of the arteries is in reality only indirectly contributory, a *force d'emprunt*, and that the heart is the sole impulsive agent which exerts an active part in the circulation. Nevertheless, I maintain my proposition: the elasticity of the arteries is favorable to the course of the blood, but it does not act as an impulsive force. *It diminishes the resistance which the heart experiences when it propels the blood in the vessels.* The annexed schematic apparatus will enable me to demonstrate this proposition.

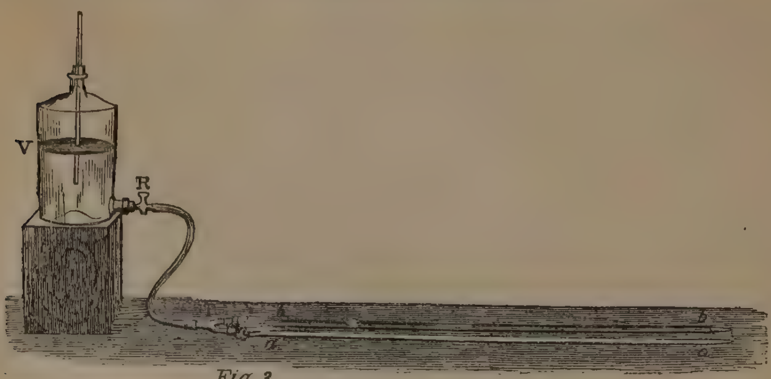


Fig. 3

A Mariotte vase V is raised on a support. From this vase proceeds a large tube furnished with a faucet R. This tube is bifurcated at the point T, and

each of its branches is continued by a long conduit. One *b b′* is elastic, being formed of thin caoutchouc; the other *a a′* is of glass, and consequently rigid. A valve, placed at the origin of the elastic tube, permits the liquid to penetrate freely into its interior, but opposes all reflux in an inverse direction. The two tubes have the same capacity of discharge: of this we may convince ourselves by opening the faucet R and allowing a continuous current to be established. But if the faucet be opened and closed alternately, it will be seen that the efflux by the inert tube is intermittent, while that by the elastic tube is continuous; it will be also found that the discharge has become very unequal, and that much less of the liquid escapes by the inert than by the elastic tube. The proposition might be considered, then, as already proved, for it is evident that if the elastic tube has discharged more liquid than the other, this results from its having received more, and as the penetration of the liquid into the tubes takes place under a constant charge, and can only be effected at the time when the faucet is open, this clearly proves that at those instants the tube of glass was more permeable than the elastic tube.

But we may form a more exact conception of what occurs under these conditions by inquiring not what issues from the tubes, but what enters them. The Mariotte vase employed as a source of supply furnishes the means of knowing accurately what penetrates into each of the tubes at a given moment, for not the smallest quantity of liquid can issue from the vase without the indication of what portion of it is withdrawn by the entrance of a more or less considerable quantity of air. Now, if the liquid be permitted to flow by the elastic tube alone, or the glass tube alone, it will be seen that in the two cases the Mariotte vase indicates very different discharges. If the efflux be by the inert tube alone, bubbles of air are seen to enter the vase one by one, at regular intervals, until the suppression of the flow of liquid, when, by the same act, the entrance of the bubbles is arrested. If, on the other hand, the inert tube being closed, the efflux commences with the elastic tube alone, a mass of air is seen on the instant to rush into the vase, announcing the escape of a wave of the liquid at the first moment; the bubbles then become more rare and enter with the same slowness which was observed in the case of efflux by the inert tube. Let the faucet be closed at this instant, and it will plainly appear that the elastic tube has received a quantity of liquid greater than that received by the inert tube and corresponding to the access of the large volume of air at the commencement of the experiment. It is this excess of liquid which occasions a flow more or less durable after the closing of the faucet. This whole quantity of water accommodated by the distension of the tube constitutes the advantage of the elastic tube as regards the afflux. If this tube more readily admits the penetration of the water into its interior, it is because the liquid is not required, as in the case of the inert tube, to overcome the total friction and flow outwardly, but finds lodgment within the tube by reason of the extensibility of the latter. It is obvious that as often as these intermittent openings of the faucet are repeated a new advantage is created in favor of the elastic tube. Finally, theory teaches us that to render the efflux by the two tubes as unequal as possible, it is requisite that the faucet should be opened, each time for a very brief period, and that the intervals between the openings should be of some duration.

The demonstration of this effect of the elasticity of the arteries, though heretofore unknown, would seem to be of much importance; it has enabled me to draw new conclusions, and to establish, for example, that if the arteries lose their elasticity, as is normally the case with aged persons, the heart must experience an increase of resistance, and, according to the known laws of pathology, become hypertrophied. The researches which I have made with a view to the verification of this prevision have furnished a complete confirmation of the theory, but I shall not insist here on particulars which enter properly into the domain of medicine, and which would divert me from my subject.

In returning to the synthetic reproduction of the phenomena which accompany life, I shall present but one other example of synthesis. The uses of the natatory bladder of fishes have been very much controverted; most naturalists, however, have considered this organ as capable of modifying the volume of the fish, and consequently its density, so as to render it sometimes lighter than the water, thus causing it to ascend to the surface; and sometimes heavier, thereby enabling it to plunge to great depths. More recently, M. Moreau resumed the study of this subject, and pursued it much further than had previously been done. His attention was first arrested by the circumstance that a fish drawn at sea from a great depth swells and sometimes bursts when brought to the surface of the water, and in this condition floats helplessly, because it has become much less dense than the water. The elastic force of the air of the bladder, resisted under normal conditions by the weight of a column of water extremely high, brings on a great distension of the animal if the pressure is diminished, so that, having become lighter than the water, it floats on the surface. Hence it follows that a fish which lives normally at great depths in the sea cannot rise above a certain altitude, under penalty of being borne to the surface by the expansion of the gas of its air-bladder. And this theoretical deduction involves a converse one: that the fish cannot descend to a depth greater than that for which its natatory bladder is adapted. If it ventures to a greater depth the gases of its bladder will undergo greater compression, the density of the animal will be augmented, and it will be precipitated indefinitely, even to the bottom of the sea; whence it can rise no more, unless it could secrete within its bladder a quantity of gas sufficient to distend it notwithstanding the enormous pressure to which it is subjected.

Fig. 4

Theory teaches us, then, that a fish is not fitted to live except at a certain depth; that it cannot all of a sudden transfer itself from a certain zone to which the state of its air-bladder assigns it; that if it emerges from that zone in which it possesses nearly the same density with the water, it must be impelled indefinitely, whether to the surface or towards the bottom of the sea. It may, moreover, be inferred that the animal can within certain limits extend this zone to which it is assigned, if it has the power of compressing or relaxing its air-bladder; that is to say, of modifying spontaneously its own density, whether in one direction or the other. It is to be understood, finally, that the fish has the faculty of contending to a certain extent, by the movements of its fins, against the effects of its own density, and thus still further enlarges the zone in which it can subsist.

The whole of these theoretical deductions can scarcely seem evident at the first glance, hence experimental control would appear to be indispensable. We know, by experience, that a fish drawn from a certain depth to the surface of the sea floats in spite of itself; but the inverse phenomenon, a fish precipitated to the bottom of the sea, is what no one has witnessed. Yet a very simple scheme will render this phenomenon perfectly evident. The apparatus for this purpose (*Fig.* 5) is analogous to the *ludion*, an instrument with which we are familiar. It is formed of a bladder of caoutchouc filled with air, and sustaining a weight graduated in such manner as to give to the whole system a density equivalent to that of water. This apparatus is placed in a glass

gauge having such a length that the liquid column shall represent a rather strong pressure, when the ludion is plunged to a certain depth. The volume of air contained in the ball is so regulated that the ludion, when at the surface of the water, is a little less dense than the liquid, and emerges from it to some extent. Let it be now sunk to a slight depth; it is still not so dense as the water and tends to rise above its surface. Sink it a little deeper, and it will remain nearly immovable in the zone in which it is placed, indicating that its density is now equal to that of the water. It is thus that it is represented in the figure. Let it be sunk more deeply and it will be seen to have a tendency to descend of itself: it has become denser than the water.

Here, then, we have a new example of the synthetic reproduction of the phenomena which occur in living animals. Many analogous examples might be cited, but it is only my purpose here to signalize the utility of this method, and to show how important it is still further to extend its application. It may be added that any one, by the construction of a schema of his own, will find that the vague ideas which he may have at first conceived on an obscure subject, acquire singular precision and development. New conceptions will be constantly presenting themselves, and problems be suggested which the mind is impatient to verify by new experiments. In a word, this manual labor of the construction of schematic apparatus, far from absorbing the mind, sustains and guides it by furnishing it at each step with an experimental test.

An objection will not fail to be made by those who pretend that there are, in living beings, properties which such persons term vital, and which are altogether peculiar. They will tell us that synthesis may well reproduce the physical phenomena which accompany life, but that it is incapable of imitating the *vital* phenomena. I will answer, for my own part, that I recognize but two sorts of manifestations of life: those which are intelligible to us, being all of a physical or chemical order; and those which are not intelligible. As regards the last, it is better to avow our ignorance than to disguise it under a semblance of explanation.

IV.—Laws in biology.

I have next to speak of *synthesis* considered as a mental operation, the opposite of analysis; as collecting dispersed ideas to form of them a whole; as ascending from particular facts to the general law which governs all of them.

The highest point which the natural sciences can reach is the discovery of the laws which govern the phenomena of life. This, as I have said, is the ideal we should pursue, but which we have not yet attained. At present it is the research for facts which occupies us; we labor in behalf of successors, perhaps far remote; we accumulate for them the materials of a vast synthesis, which will enable them to embrace all these facts under a general point of view, and to educe from them simple laws. Already, however, light seems to diffuse itself upon certain points of the sciences in question, and some of their laws have begun to emerge from the mass of details.

Let us premise this capital fact, that the laws of physics and of chemistry reappear in the manifestations of animal or vegetable life, and that every day the hypothesis which led to the admission of forces of a special nature in organized beings is becoming less and less necessary. As regards the laws of physics, we have seen them applied in the operation of the schematic apparatus by means of which we are enabled to imitate certain phenomena observed in living beings. We shall doubtless still continue to discover these same laws in proportion as we shall study in their more intimate details the functions of organized beings. As regards the laws of chemistry, Berthelot has shown them as presiding in the formation of the substances called *organic*. The hypothesis of a vital chemistry of a wholly peculiar nature is now useless. Researches based on synthesis in chemistry show us that the ordinary laws suffice to explain the formation of organic matter in the interior of vegetables.

The best known of all vegetable functions, the respiration of plants, presents this first experimental idea, that the green matter of plants, under the influence of solar light, decomposes the water and carbonic acid, thus setting at liberty the hydrogen and oxide of carbon. Now, these latter substances are the elements which chemical synthesis employs to form the ternary compounds, which may all be derived from the action of nascent hydrogen on the oxide of carbon.

If the chemist, in his laboratory, must proceed by a series of transformations in order to realize substances in which the elements are more condensed, nature attains the same end in a more direct manner, without, on that account, violating the ordinary laws of chemistry. In nature all the elements are in contact in a nascent state, so that the simpler compounds which result therefrom remain not long in their first phase of evolution, having close at hand every principle necessary for the formation of more complex bodies. Organic bodies arrive, therefore, with immediate effect at their highest degree of condensation, while, in the chemical reactions of the laboratory, we are obliged, in following up the conditions of the formation of these bodies, to create artificial and successive phases.

In the study of the functions of life, the physiologist finds himself confronted with phenomena so complex that he cannot at once comprehend the laws which govern them. But he is struck with certain characters which seem to him more constant than others. From these he deduces the existence of certain *vital laws*, an ephemeral hypothesis which disappears soon or late before a more profound investigation of the phenomena, and is absorbed in the more comprehensive generalizations of physical or chemical laws.

First of all, the production of heat and that of movement seem to him to be attributes of the animal kingdom. If some species appear to form an exception to this sort of general law which he has established, the physiologist explores the facts more attentively, and perceives that the animals which he had at first distinguished from others by calling them animals *with cold blood*, constitute but an apparent exception, and that they also produce heat, though in less quantity than others, besides that they have not the property of preserving this heat, but allow it to escape when they are placed in a cold medium. Eventually it is recognized that the chemical actions which take place in the organism are the cause of the production of heat in animals, and that the quantity of heat disengaged increases or decreases according to the intensity and nature of those actions. Thenceforth the production of animal heat presents itself only as a particular case of the disengagement of heat in chemical reactions.

Movement in animals was at first considered a direct result of life; in its apparent spontaneity, a character was even supposed to have been found which distinguished it from the movements whose laws are determined by mechanical principles. But it was at length recognized that the production of movement, like that of heat, requires in animals a chemical action; that its production, therefore, is not unlimited, but must be assimilated to the labor of our machines, which transform into movement the heat derived from the combustion of carbon. Considered under this point of view, the animal organism would not differ from our machinery, except in its more advantageous capacity of production, but can yield, on the whole, in labor only what the chemical actions exerted on the absorbed aliments will admit of. This extension of physical laws to the functions of organized beings commends itself so strongly to reason, that no hesitation is at present felt in pushing conclusions to their last consequences, and in seeking, for example, in the animal economy the verification of the law of the *equivalence* of heat and of mechanical labor.

Nothing can be more legitimate than this tendency to reduce all the phenomena of nature to simple and general laws; to me it even seems that this mode of procedure has every chance in its favor of being the right one; still, from probable hypothesis to demonstration is a long stride. On this account it is that we

must recur indefatigably to the study of particular facts, and that, without renouncing the purpose of reducing them eventually to simple laws, it is necessary in the first place to refer them to other special laws, but to such laws as are susceptible of demonstration.

Upon these grounds, certain phenomena of life may already be referred to demonstrable laws. M. Brown-Séquard, in particular, has given us, in his *Journal de la Physiologie*, a short note containing a very noticeable attempt at that generalization of which I have been speaking. This physiologist sets forth, as results of his own labors as well as those of the savants who have preceded him, *twelve laws* relative to the conditions under which nervous and muscular actions are either produced, increased or exhausted, together with certain other analogous phenomena which are observed in animals.*

Among these laws there are several which are not, perhaps, beyond the reach of criticism, and everything would lead us to believe that the further progress of science will reduce them to greater simplicity. Such as they are, however, they appear to me well worthy of remark and meditation. For some of my auditors, it is true, this generalization may be premature and difficult of comprehension; but for most of those who are somewhat initiated in biology, I would hope that they might lead to an enlarged conception of the facts with which they are already acquainted. Some of these laws, being those which are specially applicable to *muscular contraction*, are in substance as follows:

First law.—*Muscular contraction seems inseparable from an organic change which nutrition alone can repair.*

It is now known that the muscle in repose presents the alkaline reaction, and that, under the influence of repeated contractions, it passes to the acid reaction; a chemical process has therefore been at work, which has modified the composition of the muscle. Again, if we seek in a muscle the proportion of matter soluble in water, before or after energetic exertion, we shall find, with Helmholtz, that the quantity of soluble substances has augmented under the influence of that exertion.

Second law.—*The rapidity of the circulation of the blood and the richness of that liquid in restorative substances, favor the recuperation of the muscle, and render it capable of new labor.*

This law, like the preceding, is susceptible of experimental verification. We can augment or diminish the time necessary for the recuperation of the muscle by abating or accelerating the course of the blood which traverses it. The need of alimentation which follows muscular exercise also confirms this law in what relates to the influence of the qualities of the blood on the muscular restoration. Even in the absence of circulation, the restoration still takes place within certain limits, which is explained by the presence of the blood with which the tissues are saturated, even when it ceases to circulate.

Third law, (flowing from the two preceding).—*A muscle is subjected to two influences, the one restorative, nutrition; the other exhaustive, its motive function; its actual faculty of producing movement varies according as one or the other of these influences has acted.*

Hence, after a prolonged repose, the muscle has attained its maximum of aptitude to act, since the restoration is produced without waste. Conversely, after prolonged action, the faculty of acting is at its minimum. It will be seen how closely this law approximates to laws purely physical, and how much the muscle resembles an apparatus which on the one hand receives electricity, and on the other dispenses it; as it does also a body subjected to a source of heat and to an intermitting cause of refrigeration.

Fourth law.—*Recuperation after action is more rapid during the first few instants than it is afterwards.*

* In the number of these would further appear the electric phenomena observed in certain fishes, the phosphorescence of certain animals, the movement of vibratory cilia, &c.

That is to say that if, after the action of a muscle, the repose lasts one minute, there will have taken place a certain degree of restoration of the faculty of acting, and that if the repose continues for two minutes, the restoration will not have doubled the muscular energy. This likewise offers a new analogy with physical phenomena. In effect, a chilled body submitted to a source of heat, gains much heat in the first few instants, and acquires but little afterwards in proportion to the duration of the process of heating.

FIFTH LAW.—*The habitual activity of a muscle and its nutrition stand in such relation to one another that repose too much prolonged produces atrophy of the organ, while action frequently repeated increases the volume of the muscle and augments its aptitude to produce movement.*

The examples which confirm this law are well known; every one has had an opportunity of observing the development of the muscles which, in some individuals, are more exercised than the rest, and, reciprocally, the atrophy of the muscles which, for whatever reason, have been consigned to a long repose. There are limits, however, beyond which this law ceases to be true; but these limits have not yet been ascertained in a precise manner.

The laws here stated regarding the muscular function are sufficiently general to enable us to recognize them in other functions which seem to have no analogy with movement. Having incidentally mentioned the discharge of the torpedo, I may here add that it would be interesting to inquire, within what limits the laws above stated are verified in this order of phenomena. M. Brown Séquard thinks, as I have before said, that they are governed by the same laws with the muscular action; but experiment has not yet succeeded in proving the reality of this opinion, though it may be said to have every probability in its favor. The only point on which perfect identity has thus far been established consists in the fact that the discharges of the torpedo become weaker and weaker when a series of them is provoked. There is, therefore, a real exhaustion of the function simply by its own action; a fatigue of the electric organ, as there is a fatigue of the muscle.

The presence of blood in the organ and its rapid circulation seem to be essential conditions for the abundant production of electricity and its prompt restoration. Such, at least, is the conclusion which appears to result from the anatomy of the electric apparatus of these animals, so richly provided with bloodvessels; but the absence of exact means for appreciating the intensity of the discharges of the torpedo has heretofore precluded rigorous experiment on this subject.* We are able, however, as M. Moreau has shown, to verify the fact that a cessation of the current of the blood does not immediately prevent the electric apparatus from operating, any more than it extinguishes instantly the contractility of a muscle. But this suppression of the current of the blood would seem to render the exhaustion of the electricity more rapid.

It will be seen that there remain many *desiderata* in relation to the production of electric phenomena in fishes. The presence, however, of certain characters perfectly alike in the function of their electric apparatus and the muscular function should induce inquiry whether other analogies exist. It is thus that a knowledge of the laws of a phenomenon traces for us the path to be followed in the study of others, by indicating the most probable result of the researches which may be undertaken.

M. A. Moreau has happily been led by the analogy which exists between the production of electricity in the torpedo and the production of movement in the

* The galvanometers which have been employed are too sensitive; the electric discharge of the animal communicates to the needle so violent a deviation that it makes the circuit of the dial-plate several times, and does not allow a comparison of the relative intensity of the different commotions. It might be practicable, perhaps, by means of a circuit of *derivation*, to give to the instrument only a part of the current, and as, in that case, the intensity of the derived current remains proportional to that of the principal current, the variations of the intensity of the discharge might probably be appreciated.

muscle, to a study of the action of the nerves which proceed to the electric apparatus. In inquiring whether these nerves are similar to the motor-nerves, he has, in effect, found the resemblance perfect: 1. That the section of the former suppresses the spontaneous discharges of the animal, just as the section of the motor-nerves suppresses voluntary movement in the muscles to which they are distributed. 2. That the excitation of the peripheral end of an electric nerve provokes a discharge of the apparatus, as the excitation of a motor-nerve provokes a shock of the corresponding muscle. 3. That the excitation of the central end of the electric nerve provokes in the animal no phenomenon of sensibility, as none is occasioned when the central end of a nerve of movement is excited. 4. M. Moreau having poisoned a torpedo with strychnine, which communicates to the motor-nerves a series of repeated excitations and throws the muscles into tetanic convulsion, found that this drug provoked in the electric apparatus very frequent discharges, similar in all respects to the convulsions of a tetanized muscle.

The phenomena of *sensibility* are, within certain limits, subjected to the same laws with the phenomena of movement. We verify with regard to both the law which teaches us that activity exhausts the function, and that repose restores it. A lively sensation fatigues the sensibility, exhausts or abolishes it for a certain time, while by repose its previous intensity is renewed.

Let us take as an example the most complex, but at the same time most interesting of our sensitive manifestations, the sight. When we look at a very bright luminous object, the point of our retina on which its image falls is vividly excited; it becomes fatigued, and if we turn the eyes on a field of a uniform clear color, we see on it a darker spot, presenting the exact form of the bright object by which our vision had been impressed. This spot is owing to the fact that the fatigued point of our retina no longer perceives the luminous sensations with the customary intensity. The more brilliant the body observed, and the longer the time we have observed it, so much darker and more persistent is the ensuing image. Repose of the sight causes this subjective image, as it is called, gradually to disappear.

The fatigue of our retina may be restricted to certain elements of sensation, if we have received the impression of only certain elements of the light. Thus, our vision may be fatigued for the blue, the red, or the yellow separately. Suppose, for example, that a red wafer be placed on a sheet of white paper, and that we look upon it intently for some instants. Let us now remove the wafer without ceasing to look at the same point; we shall immediately see a *green* disk of the same dimensions with the wafer appear in its place. The reason thereof is: that in the white light of the paper our eye cannot perceive so vividly the red rays in the point of the retina which is fatigued with that color, and as all the other rays are there perceived, these form by their fusion the complementary color of red, namely, green. In the same way, a green wafer would leave after its disappearance a red subjective image; a yellow wafer would give a violet image, &c.

I shall not dwell longer on examples of the very general law that *every function which is exerted is momentarily exhausted, and that it is restored by repose.* Let us proceed to a brief consideration of laws of another order in the phenomena of life. We will take, for example, the influence of functions upon one another. On this subject I may be allowed to adduce certain general views which appear to me to result from the observation of phenomena and from physiological experiment. A *law of harmony among the functions of life* will, I think, be admitted without difficulty; that is to say, that if one function reacts on another it influences the latter in such manner as to derive therefrom advantage for itself. To develope this idea, I will present a few examples: It has been already said that any muscular action has need of being maintained by the circulation of the blood; now the action favors this circulation and renders it more rapid.

To leave no doubt regarding the first proposition, I proceed to support it by experimental facts. It is in effect easy to demonstrate the necessity of the sanguineous current in the exercise of a muscular action. Thus, when we tie the lower aorta in an animal, we find that the muscles of the hind quarters are quickly paralyzed. The same result follows if we inject into the arteries of a limb a fine powder, which has the effect of obliterating the small vessels. M. Flourens has shown that, under these circumstances, the muscles soon become incapable of acting. There is a malady which veterinary surgeons call intermittent claudication, and which has been attentively studied in the horse by M. Bouley and Dr. Charcot. This malady is produced by an obliteration of the iliac arteries. In this state of things a new circulation is established by the collateral vessels, but these have not the easy permeability of the large trunks whose place they tend to supply. The animal thus affected can move for some time in the usual way; but presently the afflux of blood to its muscles being no longer sufficient, a sudden paralysis takes place and the horse stops. A moment of repose re-establishes the muscular function, which is exhausted anew after a few steps. The case wholly arises from the fact that the current of blood in the muscles is no longer sufficiently rapid to maintain their function in a durable manner.

Again, let us take a frog in which the vessels of one of the hinder feet have been tied, and suppose that both feet have been excited by induced currents, and that in both the contractility has been fatigued by prolonged action. If we now excite the two feet of the animal, it will be seen that the sound foot has recovered its contractility, while that whose vessels were tied still evinces in a high degree the exhaustion consequent upon its fatigue.

Granting then the necessity of a circulation so much the more rapid as the muscular act is one of more energy and duration, it is easy to prove the second proposition which I just now advanced, namely: that this muscular act communicates of itself a greater rapidity to the circulation of the blood. Every one is aware that in venesection, if the member is motionless, the blood escapes slowly from the vein, while the flow becomes much more copious if the patient exerts contractions of the muscles of the fore-arm. The question here is not that of a simple compression of the veins by the muscles, which would mechanically express the blood contained in those vessels. Such a cause would speedily have exhausted its effect, and extruded but an inconsiderable quantity of blood. There is exerted, on the contrary, a continuous action which accelerates the course of the blood as long as the contractions of the muscles of the fore-arm are continued. A still more convincing demonstration of the influence of the muscular act on the current of the blood may be given, by showing that the arterial system is depleted in an animal which has just desisted from running and presents in its interior a more feeble pressure than in a state of repose.* From such facts as these it results that the muscular act operates on the circulation in such a way as to accelerate the course of the blood through the muscles, and thus promotes that action by which the acceleration was occasioned.

We might cite a great number of examples of this law of harmony of the functions, and show, for instance, that the venous blood, when it arrives in abundance at the lungs, stimulates that organ and provokes the respiratory movements destined to arterialize it, while the respiration, at the moment when it is executed, opens a passage for the blood on which it is to act, &c. But these reciprocal influences of the functions would exact too long developments to be thoroughly treated on this occasion. I confine myself to a notice of the existence of this *law of harmony* of which I have been speaking, the recognition of which I consider of the greatest utility, as enabling us often to foresee phenomena which experiment will verify.

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* See, for further development of this subject, Marey, *Physiologie médicale de la circulation du sang*, p. 223, Paris, 1863.

ON THE ELECTRICAL CURRENTS OF THE EARTH.

BY CHARLES MATTEUCCI.

TRANSLATED FOR THE SMITHSONIAN INSTITUTION.

The study of electric currents in the terrestrial strata dates, I think, from the discovery of the galvanometer. M. Fox, in England, was the first who saw the needle deviate when different points of a metallic vein were touched with the extremities of the wire of the galvanometer. M. Becquerel afterwards made very extensive researches on electric currents obtained between masses of water and strata of earth existing under different conditions. Till then these experiments were regarded but as obscure cases of electro-chemical action, of difficult interpretation. There was no thought, in this case, of any such thing as a terrestrial phenomenon—that is to say, of *spontaneous* electric currents, as they are called by the celebrated astronomer of Greenwich—until very strong electrical currents had been observed in telegraphic wires during the appearance of the aurora borealis. This phenomenon presented itself for the first time, November 17, 1847, in the telegraphic wires of Tuscany, while a bright aurora was visible on the horizon. The description of this phenomenon, which I gave to the French Academy in a letter addressed to M. Arago, was followed shortly afterwards by similar observations made in the United States. In late years numerous observations have been made on this subject on all telegraphic lines, and have confirmed the first results. It was natural to seek the existence of electric currents and their laws in telegraphic wires, independent of the simultaneous appearance of the aurora borealis, and the Academy of Sciences is cognizant of the researches on this subject which have been made public by such eminent savants as MM. Baumgarten, Barlow, Lloyd, and Walker. When their memoirs are read with the attention they merit, no one can fail to be struck with the difficulty which presents itself in harmonizing the results they have obtained and deducing some general consequence which might set us in the way of explaining these phenomena. All these researches have been conducted by introducing a galvanometer into telegraphic lines, and measuring the currents at such times as the lines were not in service for the transmission of despatches. Ordinary communications, established as telegraphic stations between the metallic wires and the earth, are effected, we know, in different ways; sometimes they are formed by plates of iron or copper plunged into the water of wells more or less deep, and connected with the metallic wires; sometimes these wires communicate with the shafts of pumps or with the rails of an iron road. With the exception of the distinguished astronomer of Munich, who seems, especially in his later experiments, to have duly considered the necessity of guarding against currents excited by the extremities of the lines in communication with the earth, the observers have given us no intimation how these communications were established.

Yet it is not difficult to discover on any telegraphic line taken at hazard that the currents obtained in these lines depend on the heterogeneousness of the plates which communicate with the earth. I have often seen these currents

undergo a change of sign when the position of the plates was changed or their heterogeneousness was modified by causing the current of a battery to pass in a given direction. These currents disappear, or are considerably weakened, by employing plates and liquids as homogeneous as possible. By employing more sensitive galvanometers and quite homogeneous plates of copper, it will readily be recognized that the slightest difference in the composition of the water of the terminal wells suffices to excite currents. It need scarcely be added that in operating upon telegraphic lines, it is necessary to take account of the secondary polarities which the currents of the battery develop, sometimes in one direction, sometimes in the other. Telegraphic lines have also other causes of error due to the variable contact of the wire with the posts. From the moment when I proposed to study this subject, I felt convinced that, before aught else, it was necessary to possess a method by which would be realized the condition of having long conducting wires, perfectly isolated, extended in definite directions, the communications of which with the earth should be absolutely homogeneous, and which should form mixed circuits, all endowed with the same conductibility. It was in the following manner that I attained these objects:

The wire which I employed was of copper, two millimetres in diameter, and covered with gutta-percha; this wire was suspended by means of a sort of cleft, wrought in the top of a rod or slender post of wood, such as is in use here for military telegraphic lines. These wooden rods were planted at a distance of 25 or 30 metres from one another, in two lines exactly traced, one in the magnetic meridian, the other perpendicular to the meridian. Each of these lines was six kilometres in length, the place where they were established being the plain of Saint Maurice, 22 kilometres from Turin, a plain set apart for military exercises. The communications between the extremities of the wire and the earth were effected in the following manner. At the extremity of each line I caused to be dug a kind of pit of rectangular form, two metres in depth and length, and one in breadth; at the bottom of this pit was formed a cavity much smaller, and which might be termed a sort of capsule, having a width and depth of 30 centimetres. A bed of clay, such as is used in the fabrication of pottery, was carefully spread over the interior surface of this capsule, so as to prevent the water from percolating too rapidly through its wall. The same water, being that from a river, was employed for the four cavities, and the person appointed to superintend at each extremity had a supply of this water at hand, in order to maintain it constantly at the same level. Lastly, a porous cylinder, such as is used for the batteries of Daniell, filled with a saturated and neutral solution of the sulphate of zinc, was plunged in the water at the centre of the cavity, and the wire of the line was united to a plate of zinc perfectly amalgamated, and which in turn descended into the solution of the sulphate. The porous cylinders thus prepared and the plates employed were tested in advance, and this testing was renewed from time to time, so as to be sure that the plates were perfectly homogeneous. It rarely happens that two plates once rendered properly homogeneous undergo alteration for several days when they remain constantly immersed in the solution. Should, however, a slight heterogeneity appear, it will suffice to wash and amalgamate them anew, in order to render them again homogeneous. The two lines also must be ascertained in advance to have the same conductibility. In a uniform plain, like that in which I operated, the pits being excavated in nearly the same stratum, the differences of conductibility could not be great; but I succeeded in rendering them equal by deepening by a few centimetres the cavities made at the bottom of the pits of that line which was found to be most resistant.

In this manner the conditions of the circuit which I deem essential for these experiments were realized. It is proper to remark that, wishing to test in advance two similar excavations, with cavities at the bottom as above described, and formed at a distance of five to six meters from one another, I found no trace of a

current between these cavities, as I had obtained none in employing the two porous cylinders with their plates of zinc plunged in a vat filled with water. I proposed also to test beforehand whether the nature of the formations in which the pits were excavated might have some influence. With this view I caused the earth proceeding from the excavation of pits near the place where I was established to be transported, and two cavities formed in a neighboring field to be filled with it; having then introduced into this earth, in the manner already described, the extremities of the galvanometer, I obtained no sign of a current.

Very near the place where the two lines, north-south and east-west, crossed one another, each of the lines was interrupted, and the extremities thus obtained were passed into two capsules filled with mercury in the chamber where I had stationed myself with the galvanometer. I employed alternately three galvanometers—one of 1,500 coils, another of 100, and a third of 24,000 coils; the numbers which I shall report in my memoir were obtained with the first of them.

I must be excused for these long details on the process which I employed; I have thought it necessary to give them, as well by reason of the importance of such researches as of the difficulties and uncertainty met with in the investigations which I have before cited. I continued the experiments on the two lines for nearly a month, from the 12th or 15th of March to the 15th of April of the present year, during which time the weather was generally fair, the air cold and dry, the sun very warm. I cannot report in this abstract all the numbers obtained in this long series of experiments; for ten days the observations were made almost hour by hour, with a change of observers. I am compelled, therefore, to give here only a recapitulation of the results at which I have arrived.

1. In two circuits, formed in the manner which I have described, it is rare not to find electric currents more or less constant, whose origin cannot be attributed absolutely to the heterogeneousness of the terminal metallic plates, nor to chemical action between the water in which the plates are immersed and the terrestrial strata.

2. These currents augment in intensity by deepening the cavities into which the terminal plates are plunged from $0^{m}.50$ to 2 metres; the greater conductibility found in the mixed line by deepening the terminal cavities accounts for this result. The same may be said of the slight and transient augmentation of the electric currents which is realized by the effect of rain on the earth immediately surrounding the cavities in which the electrodes are plunged.

3. It has not been found that the extent of the plates of zinc and the diameter of the porous vessels have a distinctly marked influence on the intensity of these currents, when operating at a depth of two metres.

4. In the meridian or south-north line, the current has always maintained a constant direction; hundreds of observations have continually shown that the current entered the galvanometer by the metallic line coming from the south, and issued from it through the line directed to the north. By comparing the very nearly conformable deviations obtained in this great number of observations, it would appear that this current presents in the 24 hours two *maximums* and two *minimums* of intensity. The two minimums occur during the day and in the night, at nearly the same hours, that is from 11 to 1 o'clock. After 1 o'clock in the night, the current augments and attains a maximum at from 5 to 7 o'clock in the morning. In the day this maximum oscillates between 3 and 7 o'clock in the afternoon. The difference of intensity between the maximums and the minimums of intensity is greater than that of 1 to 2.

5. In the equatorial line the results are very different, and subject to great variations. Frequently the needle rests at 0°, frequently it oscillates, sometimes into one quadrant, sometimes into the other, ranging from two to three degrees, and even 14° and 15° on the same side, and often oscillating around 0°. The direction of these currents, which has occurred most frequently in the equatorial line, was from west to east.

6. By establishing communications between the lines south-east, south-west, and north-east, north-west, the currents realized were generally those which circulated in the portion of the line pertaining to the south-north line.

7. Only the temperature more or less elevated, which varied from 0° at night to + 14° or 20° by day, was ever observed; the humidity or dryness of the air, and even stormy weather, had an influence on the direction and intensity of the current of the meridian line.

8. The results have been the same, whether the metallic portion of the line was suspended on posts or laid upon the surface of the ground.

What is the origin of these currents? I believe it impossible to answer this question with any confidence. What ought to be considered as perfectly proved by experiment is, that in a wire, when it reaches a certain length and its extremities are in good communication with the earth, there is an electric current which constantly circulates, and principally in the direction of the magnetic meridian; the origin of this current is neither in the metallic part of the circuit, nor in the terminal metallic plates, nor in any chemical action which might be surmised between the terrestrial strata and these plates, or the liquids in which they are immersed.

Should these currents be considered as derived currents? I have heretofore demonstrated, what every one at present admits, and which is accordant with theory, that the resistance of a terrestrial stratum is very nearly null and does not vary with the length of that stratum. These considerations are not favorable to the idea that the currents we have described are derived currents. On the plain of Saint Maurice, I have made some experiments to ascertain to what distance from the electrodes of the battery derived currents were sensible. I used for extremities of the derived circuit the same plates of zinc plunged in the saturated solution of the sulphate of zinc which have been described above. The circuit of the pile was six kilometres in length; its extremities consisted of square plates of copper, 20 centimetres to the side, immersed in water to the depth of two metres. The battery was composed of 20 elements of Daniell; the galvanometer of the derived circuit was that of 1,500 coils, before mentioned. When each of the electrodes of the derived circuit was at a distance of 10 metres from the electrodes of the battery, in a straight line between these electrodes, I obtained a steady derived current of 33°; this deviation remained constant during the whole time that the current of the battery did not vary, that is for several hours. On increasing, to 50 metres, the distance between the electrodes of the battery and those of the derived circuit, there were 4° of derived current; at 100 metres this deviation was barely half a degree; and at a distance of 200 metres, it is doubtful whether there was any movement at all in the galvanometer at the closing of the circuit of the battery. It seems to me difficult to derive from these experiments any satisfactory reply as to the nature of the electric currents observed in long mixed lines.

General Sabine, the highest authority of the present day in point of terrestrial magnetism, appears to admit absolutely the magnetic influence of the sun upon the earth. But, if this influence be admitted, what explanation can be given of the currents we obtained and the differences of those currents according as the line is in the meridian or perpendicular to it, or the periods of intensity in the former of these lines? Assuredly these currents cannot be currents of induction due to the rotation of the earth. It is stated that Father Secchi, the indefatigable astronomer of Rome, is occupied at this time in investigating the connection which exists between the electric currents of long mixed lines and the variations observed in the instruments which measure the magnetic force of the earth. If a connection of this kind were well established, we should certainly have taken a step towards the interpretation of the electric phenomena of the earth.

It remains to report a result which has some importance, and which I have constantly realized: These terrestrial currents have a greater intensity, in the

case of a mixed line, when, the distance between the extremities remaining the same, the terminal cavities which constitute the communication between the wires and the earth are at different levels, than when these communications are established in a horizontal plane. For the verification of this, I have established on the heights of Turin a line whose wire, in a straight direction, has a length of scarcely 600 metres, while the terminal cavities have a difference of level of nearly 150 metres. The line which joins the two cavities is in an intermediate direction, or southeast and northwest. The current has circulated constantly, for five or six months, from below upwards in the wire, or from the northwest to the southwest extremity. All the precautions which I have before described were observed in the construction of the cavities in which the plates of zinc are sunk, and I am certain that the current obtained depends neither on any heterogeneousness in the wire, nor on the terminal plates, nor on a chemical action between the plates and the terrestrial strata in which they are imbedded. When care is taken, as I have practiced for several days in succession, to maintain at a constant height the liquids of the terminal cavities, that is to say, the water and the solution of sulphate in the porous vessels, the deviation remains nearly invariable, whatever may be the state of the sky and temperature of the air, and only after quite a long rain has the deviation temporarily increased. In this line I have not remarked the periods of which I have spoken. Other lines of nearly the same length, established in similar formations at the foot of the hill on a horizontal plane, yielded no sensible deviation.

If the influence of the difference of level of the extremities of the metallic line should be verified in a great number of different cases, if the direction of the current in the wire should prove constant, that is to say, always from below upwards, might we not be tempted to attribute these currents to the negative electric state of the earth, the tension of which is then unequal between the plain and the elevated points, as we find in an electrified globe communicating with a metallic point? As the signs of the positive electricity of the air are seen in effect to augment in proportion as we ascend in the atmosphere, so also are the signs of negative electricity found to be stronger in ascending, when an isolated copper wire, one extremity of which communicates with the earth, is carried with the other extremity in contact with the ball of the electroscope. This explanation might be submitted to proof when the atmosphere presents for a certain time signs of negative electricity. I have sometimes obtained very transient signs of this electricity at the approach of storms of rain, without noticing any variation in the current of the line.

My chief object has been to investigate the relation which exists between these currents and atmospheric electricity, and next, to verify the result obtained and described in the first part of this memoir, by studying these currents in lines, the extremities of which are sunk in the earth at different levels. The first experiments were made upon the line above described, between the hill of Turin and the adjacent plain. The extremities, as has been already said, were terminated by plates of amalgamated zinc immersed in a saturated solution of sulphate of zinc contained in a porous vessel, which was plunged in turn in the water of a sort of capsule excavated from one to two metres below the surface of the earth. This mode of constructing the mixed* line is the only one which yields sure and constant results, and I would advise all physicists who occupy themselves with the subject not to deviate from it. The water which filled the two cavities was the same, and care was taken to maintain it at a constant level. During several days of July, in the present year, I have continued to observe from hour to hour the deviations of the galvanometer inserted in this line; the current was always an ascending one in the wire, though I changed several times the position and

* By this term we understand a circuit composed of an extended wire and the strata of earth intervening between its extremities.—*J. H.*

the ground in which the terminal cavities were dug, and the deviation was not found to vary in a lapse of many days, provided there was neither tempest nor rain. After rain, the deviation was constantly seen to increase. I have satisfied myself, by measuring a constant current transmitted in this mixed circuit, that the augmentation which followed rain was only the effect of the better conductibility of the earth depending on a state of greater humidity in the terrestrial stratum immediately in contact with the extremities of the line. And, in fact, it could be obtained by pouring around the cavity in which the electrodes were plunged, within a radius of two to three metres, a few buckets of water.

I have tried the immersion of the electrodes in the water of a well, which was effected by a very simple contrivance. For this purpose, I take a thick square piece of cork and fix, in a hole made in this cork, porous vessels filled with sulphate of zinc. The cork suspended by a cord floats on the water of the well into which the porous vessels descend; by means of a copper wire covered with gutta-percha and bound to the cord, the electrode of zinc was introduced into the porous vessel and communicated with the line. I was thus able to establish the mixed line, employing the well water as extremities of the terrestrial stratum, in which the electrodes were sunk. With this arrangement, also, I have realized an ascending current in the wire, and the deviation was only a few degrees greater than that of the current obtained by using the artificial cavities or pits which I have described above. By using the wells we have this advantage: that the conditions of conductibility of the terrestrial strata into which the electrodes are introduced remain invariable. It is necessary to ascertain in advance that the waters of the two wells, when those which we employ are in two cavities formed in the earth at a short distance from one another, do not yield an electric current. I have varied as far as possible the excavations situated at different levels, but in all cases have found the current in the metallic line to be an ascending one. I was even enabled to divide the line at the hill of Turin, a length of nearly 600 metres, about midway where there existed a well, and this remarkable and constant result was realized: that, notwithstanding the greater resistance of the entire line, the current, which continued to be ascendant in the two halves, had still a less intensity in the two lines taken separately than in the entire line.

I have had an opportunity of observing in these lines the effects of two or three storms during the month of July. I will first remark, that I have satisfied myself that in leaving one of the extremities of the line in communication with the electrode and the earth, and the other in the air, I had never any trace of a current, even when using a galvanometer of 24,000 coils. I have often made the experiment of putting an isolated metallic vessel, at the end of a wooden staff from seven to eight metres high, in communication with the extremity of the line which was in the air; placing in the vessel sometimes lighted coals, sometimes touch-wood, sometimes shavings saturated with burning alcohol, in order to obtain a large flame and a current of heated air. In all these experiments, whichever might be the extremity of the line immersed in the water or raised in the air, I have never obtained a sign of the current in the most delicate galvanometer, provided care were observed to isolate the line effectually and no account were taken of the indications of the galvanometer at the moment when it was necessary to touch the line with the hands.

Neither, during storms, have I observed, with the line, which was only 600 metres in length, any deviation in the needle at the moment when lightning flashed between clouds, provided the two extremities of the line are not in communication with the ground. When this communication is established and a deviation of the needle has resulted from the terrestrial current, a sudden movement is seen to take place at each flash, such as would be occasioned by the discharge of the torpedo fish. I observed at the same time the galvanometer and an electroscope of dry batteries *(à piles sèches)* communicating with an iron wire from seven to eight metres long, well isolated and raised in the air, and having

a piece of lighted touch-wood at the upper extremity. Most frequently the electroscope gave signs more or less strong of positive electricity, which augmented suddenly at the moment of the flash. At the same instant the needle of the galvanometer made a deviation of at least 15° to 20°. This sudden deviation was always in the same direction, indicating an ascending current in the wire, and was additional to the terrestrial current. It should be remarked that I have had the opportunity of making this observation in a case in which, on account of plates of copper being employed as electrodes, the current of the line was contrary to the terrestrial current which is constantly obtained with electrodes of zinc.

Thus, then, the ascending current in the wire whose extremities are sunk in cavities which have a difference of level of about 150 metres, and which, from the manner of operating, must be regarded as a terrestrial current independent of the chemical actions of the electrodes and the strata of the earth—this current, I say, augments suddenly at the moment when there is an electric discharge between clouds. There remains here an important observation to be made, in which, as yet, I have not been able to succeed: to notice, namely, what would happen when the atmospheric electricity is negative.

I have deemed it of some importance for the theory of these phenomena to substitute for the iron wire suspended on bells of porcelain, a copper wire covered with gutta-percha laid upon the earth and buried as much as possible in the grass and under the leaves. None of the phenomena before described in the suspended line, whether with a clear sky or during storms, have been modified by this change of the metallic line. We can conceive that during the flash of lightning, at the moment when an electrified cloud, which had acted by influence on the points of the ground placed within its sphere of action, discharges itself and suddenly ceases to act, a sudden neutralization may take place in the conducting wire, producing the electrical effect noticed with the galvanometer.

It remains for me to report the results I have obtained by operating on telegraphic lines of great length and whose extremities were at a great difference of level. I employed the same galvanometer and the same process of communication for the extremities of the line with the earth, that is to say, plates of amalgamated zinc, immersed in sulphate of zinc, contained in porous vessels floating on the water in the manner I have described. I have made three series of experiments, one on the telegraphic line from Ivrée to Saint Vincent, in the valley of Aosta, 36 kilometres in length, and in which the difference of level of the extremities was 281 metres. The second series was made on the line from Saint Vincent to Aosta, 25 kilometres long, the difference of level of the extremities being 83 metres. The third line, 27 kilometres in length, passed from Aosta to Courmajeur, at the extremity of the valley, and the difference of level of the two extremities was 642 metres. The electrodes of zinc were sunk in cavities dug in the ground to the depth of about half a metre. These cavities I caused to be filled with the whitish water proceeding from the glaciers, which flows in great abundance in the valley; being that which, under the circumstances, might be considered as having in every respect the same composition. I should state that the line from Ivree to Saint Vincent is nearly parallel to the meridian, while the other, from Saint Vincent to Courmajeur, intersects the former almost perpendicularly.

The following were the results obtained. The electric currents in these three lines, notwithstanding the much greater resistance in comparison with the line of 600 metres on which I had previously operated, were stronger; as were also the regular deviations, so as to rise from 40° to 60°, and even 80°, instead of 20° and 25°, which I had realized on the hill of Turin. The experiments were made at very different hours, but the regular deviation indicated in every case an *ascending* current in the wire, as in the experiments on the line of the hill just mentioned. In the greater number of cases, the deviation of the needle

remained at the same angle during the whole experiment, which sometimes continued for an hour; but I have observed also, without any change having occurred in the state of the sky, a movement in the needle almost periodic. Twice I have seen the needle deviate at first by an ascending current, and after some minutes descend to zero, then pass into the opposite quadrant and return afterwards to the previous deviation, becoming eventually fixed under the action of the current ascending in the wire. It has seemed to me that this phenomenon was presented when the water which filled the cavities of the electrodes was in movement and flowed rapidly away around the porous vessels. Reflection on the conditions under which we are compelled to operate in this sort of experiments, will suffice to evince the difficulty of solving all the doubts which may present themselves in the prosecution of our inquiries.

Notwithstanding the difficulties inherent in such researches, and which impose on the physicist the greatest reserve in his conclusions, we may regard, I think, the following results as founded on a large number of facts conformable with one another and obtained under different circumstances:

When a metallic line is stretched upon the earth, but isolated from it, while the extremities of the wire communicate with the earth at two points having a different elevation, an electric current circulates constantly in the wire, the cause of which current can be attributed neither to the chemical action of the electrodes, nor to that of the terrestrial strata in which they are sunk.

This current is constantly directed in the wire from the lowest towards the highest point, and its intensity is greater in the longer lines and as the difference of level of the extremities is more considerable.

The intensity of this current does not vary sensibly with the depth of the cavities in which the electrodes are sunk, and is the same in the wire suspended at some metres from the ground as in that which is in contact with it.

Two circumstances present themselves as constantly associated with this phenomenon, circumstances which, by their analogies, may assist in explaining it; I mean the difference of temperature of the two extreme points and the difference of electric tension of these points. I shall only remark here that I could cite results in which the influence of difference of temperature could not be considered as cause of this phenomenon, which to me appears to be due to terrestrial electricity.

CONSIDERATIONS ON ELECTRICITY.

Translated for the Smithsonian Institution from the Leipsic periodical "Aus der Natur," &c., 1865.

There is nothing about which more speculation is indulged than electricity. The word is in every mouth; yet is there nothing perhaps so little known.

What, then, is electricity? At this question even the most learned remain silent; but these are at least so honest as not to dissemble their ignorance. The unlearned would probably answer: electricity is lightning; and, though nothing is thereby gained, by this explanation the generality are satisfied. But what is lightning? Natural electricity. Let us, then, frankly confess our ignorance; the avowal can incur no reproach. Till now the part of physics which deals with electricity has been principally occupied in collecting a mass of isolated facts, which are often without connection with one another. They may be likened, therefore, to single stones awaiting arrangement in a building on some determined plan. These facts in like manner wait to be combined in a science, and connected with one another by means of a general theory. Scarcely has the way thereto been pointed out, though these facts have been grouped together under a number of subordinate laws, as, for instance, the phenomena of electrical distribution of statical induction, and the operation of electrical currents upon the magnet and their effect on one another. These are indications by which we must be guided in further advances; laws which a future more comprehensive theory must connect and explain. Let it, in the mean time, be known that all which has been with great pains wrested from nature still leaves us in the uncertainty arising from frequent chasms and insecure hypothesis.

The consistency of true science demands that experience should have first disclosed the fundamental facts; that next the inquirer, with eyes aided by every resource of art and with balance in hand, should seek to conciliate with one another, through their relations, the different and often deceptive phenomena which determine those relations. Nor is this all; on the contrary, here begins the real labor. A law must be found for these empirical facts; this may be sometimes simple, sometimes complex, but must always be a mathematical one and capable of being expressed through formulas. This general law being once found, it remains to deduce all possible consequences from it, and again to verify these consequences by experiment.

True science is a connection of fundamental facts, with laws which are derived from those facts, and deductions which have been subjected to verification. So long as one of these three stages is wanting the science is not complete. Optics and astronomy have arrived at that point; but how is it with electricity? We still stand in the presence of groups of facts which yet wait to be connected under a general law.

Let it not be said, then, that electricity is the single science which comprehends in itself all the rest. Let it not be proclaimed in the streets that our century, which has called forth the electric telegraph, may sleep in peace, and has nothing more left for it to do. Were it not, on the contrary, more judicious to say that we have as yet scarcely accomplished anything? Better were it certainly for electricity if we kept in reserve a little of our admiration, instead of lavishing it on the consideration of what has already been achieved. Perhaps

the future has more in store for us than we have, by hazard, so to say, hitherto found. The riddle is propounded; let us earnestly seek its solution. This, according to the fine expression of Pliny, is still hidden in the mysterious majesty of nature.

That the most mistaken views upon the subject of electricity are widely current is scarcely a matter of doubt. The "natural-born" inventors are expressly governed by the idea of constructing an electric battery which shall cost nothing. This is with them a fixed idea, which can be shaken by no scientific discussion. Yet what that is new and noteworthy has resulted from their attempts? Nothing worth speaking of. All improvements of electrical batteries which have really been adopted into practice are but variations of the models furnished by Grove, Bunsen, Becquerel, and Daniell. In every electrical battery we have to keep in view the intensity of the development of electricity and its constancy. According to circumstances, one of these must be sacrificed to the other. If the inventor aims to construct a battery which shall occasion the least possible expense, he must of necessity occupy himself chiefly with the constancy; since, for a single element, the intensity of the current depends exclusively on the electro-motive force of the electro-positive substance which is employed. In this respect zinc, among all ordinary metals, occupies the first place. With the alloys nothing has been attempted on account of the secondary phenomena which here present themselves. It cannot, therefore, but be useful to give a comparative statement of the electro-motive force of different metals in relation to zinc, which always holds the first place, and is therefore marked as 100; especially as so-called practical men seem to have little knowledge on the subject. This comparison shows the energy of the principal solutions to which we can have recourse in practice, upon the metals which industry has placed at our service.

	Distilled water.	Chlorine water.	Water with 1-10 sulphuric acid.	Water with 1-11 hydro-chloric acid.
Potassium amalgam, (quicksilver, 100 parts; potassium, 1 part.)	....	152.2	....	....
Amalgam of zinc	....	....	103.2	102.1
Lead	66.4	74.9	65.9	65.7
Tin	....	75.4	61.5	66.4
Iron	55.4	76.3	51.4	61.4
Aluminum	....	....	45.1	82.4
Nickel	....	....	43.9	47.8
Bismuth	....	45.9	37.2	46.6
Antimony	....	48.8	35.0	35.5
Copper	10.0	55.5	35.0	45.4
Silver	....	50.8	21.8	33.6
Quicksilver	....	....	31.6	....
Gold	....	9.2	0	....
Platina	....	....	0	....

Thus it will be seen that the intensity of the current developed depends on the chemical action exerted by the liquid on the metal: chlorine, for instance, imparts to the copper and silver a considerable degree of electro-motive force. If we would employ the alkalies as the operative liquid, the order of the electro-motive forces would be different; foremost in this case would stand: potassium, aluminum, zinc; and then would follow: antimony, bismuth, and copper. It has been sometimes proposed to make use of the sulphuric combinations as sources of electro-motive force; sulphuret of potassium would then be certainly the most applicable, but practice has shown that with this no advantageous result has been obtained. Inventors, who are choosing the solution for a superior battery of a

single pair, may determine in advance the electro-motive force of their combination through the difference of the electro-motive forces of the metals which they immerse in the selected liquid.

The first part of the problem is therefore fixed; inventors must, consequently, not step beyond this narrow circle. The choice of the metal and the liquid depend on the chemical operation upon one another, for thence results the electro-motive force. Upon the question of practical economy it would be useless here to insist, as the attention of the industrial inventor will of itself be sufficiently directed to this point.

The sources of a competent electro-motive force having been discovered, and the degree of intensity determined, next arises the question of persistency. The essential fact is here too easily forgotten, that the total intensity of a compound pair is equal to the sum of the intensity of the chemical reaction of the liquid on the electro-negative element, and of that of this liquid on the depolarizing substance, while the total intensity of a single pair is equal to the difference between the intensity of the chemical activity and that which inversely proceeds from the intensity determined through the polarizing current. So soon as the inventor leaves out of consideration essential elements, chance alone can lead him to a satisfactory solution. Whatever liquid and metal be employed, there always takes place a change of the latter, and a development of hydrogen gas which collects about the positive electrode, whether this be metal or charcoal. The inventor must therefore contrive that this gas shall be absorbed as completely and at as cheap a rate as possible. Acids, oxygen, salts, and combinations of chlorine have hitherto been alone used.

The question as to what active metal should be employed in electrical batteries, is already well nigh exhausted. Only inventors entirely ignorant of the grounds of its preference seek to replace zinc by some cheaper metal in order to obtain an equivalent amount of electro-motive force. Some have had recourse to the alloys, but they have not paid sufficient attention to the secondary currents, which nevertheless play so considerable a part in the action of an electrical battery. On this account even iron and lead, which their comparative cheapness seems so strongly to recommend, can be no substitute for zinc; for by reason of the variable contents of foreign admixtures it would be impossible to count upon uniform electrical intensities. If it be true that the electrical function of quicksilver in the amalgam of zinc is not known, yet its influence cannot be denied; but it must not be supposed that this resource is applicable to iron, tin, or lead, for these metals are still less adapted to amalgamation. The value of their electro-motive force, when brought into contact with diluted sulphuric acid, refers itself to tests which are as chemically pure as possible.

The chemists are at present engaged in researches for the discovery of new metals, but they have as yet found only metals of alkalies or alkaline earths, of which it would seem almost impossible that large masses should be furnished. So soon as these metals shall have passed into the service of practical industry, as is already the case with sodium, aluminum, and magnesium, there is reason to hope that an electro-positive element for the electric battery will be discovered, which shall be as potent as zinc. The so-called spectroscopic metals will in this respect probably be not far removed from potassium and sodium.

The choice of the liquid does not absolutely depend on that of the metal which forms the electro-positive element; we must here keep in view also the duration of the action of the battery and the chemical nature of the depolarizing substance. If only the energy be regarded and the duration of action be limited, the intensity of chemical activity is of greatest interest; for amalgamated zinc, diluted sulphuric acid, is then preferably as the active liquid. It is not unimportant here to remark that the electro-motive force is not increased with the degree of strength of the acid. Electro-motive force and resistance are words only too often used without being sufficiently comprehended. Inventors who aim at con-

structing a battery of extraordinary intensity often take no consideration thereof, and yet every elementary work on physics tells them that "the intensity of an electrical pair is directly proportional to its electro-motive force, and inversely to the total resistance."

Muriatic acid, chlorine dissolved in water, or a chloride, would be active agents almost as energetic as sulphuric acid, but less practical, with the exception of common salt. Soda dissolved in water would act energetically upon zinc, but the equivalent of electricity thereby generated would be very expensive. A pair whose active element should be aluminum and a solution of soda would possess very great energy, but would be truly an article of luxury.

The controversy is greater when the choice of the depolarizing material and the arrangement of the pair is in question. A methodical study should not allow itself to be misled, however great may be the combination; the observer must pay attention to the two essential elements, which most inventors neglect. We know the opposite influence of both the substances which surround the electrodes; we know, also, that the total electro-motive force is the sum of those which are developed in the interior of the pair between the different elements of which it consists; the analysis must therefore be extended to these partial actions. Account must then be taken of the conductibility which is proper to the elements themselves, and of the influence which their arrangement exerts on the resistance of the pair. The electro-motive force is of course in each pair independent of the disposition, the dimensions, and the nature of the diaphragms.

The three other points to be considered in the arrangement of an electrical battery, the choice of the positive electrode, the dividing walls, and the general disposition of the pair, are exclusively dependent on the resistance which they oppose to the conductibility. The positive electrode must be as perfect a conductor as possible, and on this account the purest possible metal must be employed; to supply such, however, is very costly. The use of platina has been renounced, as it is mechanically wasted. For batteries of very energetic action, as those with nitric acid, chlorides, &c., coke or retort coal would seem to be the only proper conductor. But this substance, as furnished in trade, is found upon trial to have very different qualities. Some specimens resist fracture and conduct well, while others are very porous and frangible, so that sometimes the elements of one and the same battery differ greatly in the intensity.

This inconvenience, which is founded on the inconstant nature of the positive conductor, is diminished with elements of weaker intensity, where the depolarizing substance is a metallic salt, whether in solution or solid. Here we may plainly adopt the same metal which forms the base of the salt. The conducting surface is then, through the action of the pair itself, always maintained in a state of absolute purity. The constancy of the intensity of a pair results from the maintenance of a continual identity in the surfaces of both conductors. Much, moreover, is gained in this way as regards expense, for it is the only means of completely recovering the costly substance which is employed in the depolarization. Another inducement for adopting for the positive electrode the same metal which is contained in the salt surrounding it results from a consideration already presented. Since the total electro-motive force of the pair is the sum of those forces which are developed in the different parts, it must be an object of interest to limit that force which proceeds from the contact of the positive electrode, when opposed to the principal intensity in consequence of the attack of the electro-positive metal, and on the other hand to develop that which is similarly directed with this intensity. The latter will generally be the case, if the neutral salt and the metal are sufficiently pure.

The choice of the depolarizing substance must be decided by the following considerations: by its affinity for hydrogen, in order that it may be readily and completely reduced; by the nature and physical condition of the precipitated metal, when it is a metallic salt, and by the chemical condition of the products

which originate under other circumstances. Thus, for example, from nitric acid proceed many products of decomposition which are set free in the acid and weaken its capacity for the absorption of hydrogen. The action ceases perhaps only in consequence of the excessive resistance which the depolarizing liquid so quickly assumes. This cessation supervenes more speedily with the combinations of oxygen heretofore tried; besides that they are very costly and yield residuums which are of no value. Batteries of this order are generally very intense for a certain number of hours, but their intensity then diminishes very rapidly, for the twofold reason already mentioned. The metallic salts, which exert scarcely any influence on the acting liquid, better preserve their intensity. Since they are readily reduced, it is only their conductibility which comes into consideration. As the immersed electrode is of the same nature, it will for some time be improved at the expense of the salt, and in consequence of this reaction will also maintain the physical uniformity in its vicinity.

Any advice respecting the diaphrams must necessarily be very precarious; they are detrimental through the resistance which they occasion and on account of the want of identity in their constitution.

The inventor of an electrical battery has still to pay attention to the conductibility. It must be here remembered that the chemical decompositions proceed in fixed proportions, and since, as soon as the current circulates, each pair in a battery acts as a decomposing apparatus, and each performs the same labor, it suffices to determine the performance of but one pair in order to be able to compute that of the whole battery. The weight of the copper precipitated in a voltameter is directly proportional to the electro-motive force of the pair, and is in inverse proportion to the resistance. As, according to the electro-chemical law, for one equivalent of the precipitated copper, one equivalent of zinc and a corresponding quantity of the acid are consumed, we have the means of ascertaining the cost at which the pair operates. In reality, however, this is greater than the theoretical estimate.

ELECTRICITY.

From General G. W. Dodge, U. S. A., Fort Leavenworth, March 16, 1866.

My corps (the 16th) reached Reswell Sunday noon, July 10, 1865, and we immediately crossed the river, and worked until Wednesday night putting in a double-track trestle bridge. The weather was excessively hot, the hottest, I think, we experienced during the campaign. On the south side of the river my corps was formed very compact in a *téte du pont*, covering the bridge, for I had all my artillery in position, and most of the infantry had their arms stacked, as there were heavy details for work on the bridge. It was finished about 5 p. m. Wednesday, and the 15th corps, which arrived there that day, commenced crossing about 6 p. m. A gale of wind arose, blowing terrifically for 15 minutes, when the thunder-shower came on, the rain pouring down in torrents, and the thunder and lightning close together, and hardly any distinction from one peal to another. It was so strong that at times the 15th corps had to halt. This corps was crossing the bridge during the storm, and passed directly through my lines, and went to the left, there not being room in rear of my entrenchments for it to bivouac, and it was halted right on the road and on the bridge, thus being in the midst of my corps at the heaviest part of the shower. The lightning first struck on the hill, on the south side of the river, in a battery in position; then in a regiment of infantry a short distance to the right; then on the north side of the bridge, in the valley, and right at the head of the bridge, where my pioneer corps was camped, killing one man and several mules. During this time it struck one or two other points, doing no damage, however. Horses and men in the 15th corps, on the bridge, were knocked down, but not materially injured; and a great many in the 15th and 16th corps felt the shock. It was the most destructive in the battery. In my corps 33 or 34 were killed or wounded, and quite a number—I believe 18, but I may be mistaken—were killed outright. The wounded were burned, paralyzed, and shocked—some severely, some slightly, but all had to be put in hospital. On the bodies of the killed could be traced the tracks of the lightning; so I was told, but I did not examine them. They were not much, if any, mutilated; and I remember it was spoken of that one or two of the killed had not even a trace on them. Several stacks of muskets were struck, bent up, butts split, &c. It was one of the most terrific storms I ever experienced, and the lightning appeared to strike close around us at every flash for nearly half an hour. It struck close to my tents, so close that all in them felt the shock sensibly. They were pitched on the bluffs north of the river, one-half mile from the line, where most of the damage was done. No persons were injured except in my corps. It was Lieutenant Maury's light battery F, 2d United States artillery, that suffered most. I forget the regiments of infantry, but it included two or three.

I think the storm came from the northwest, but I will not be certain about this. I know that, although it was only six o'clock or thereabouts, it was so dark that we could not see. The heavens were very black, and all light of day seemed to be shut out. The ground, trees, and some stone buildings we had erected were struck. The storm did not extend very far to the north of us, nor to the south. Its track seemed to be from the northwest to the southeast. I ordered the medical officer to make a full report, stating the circumstances, the nature of the wounds on both killed and wounded, which was done, and properly

forwarded. From that data, if it can be found, more definite and accurate information can be obtained.

Note from General O. M. Poe, U. S. A., in relation to the above:

"At the time of the remarkable electrical discharge, of which General Dodge sent you some account, he was in command of that portion of the 16th army corps, which accompanied General Sherman in his Atlanta campaign. His command was at Reswell, Georgia, where they built the bridge referred to, and a portion of the force had crossed to the southern bank of the Chattahoochie river, and it was among this latter force that the casualties occurred.

"Reswell is situated on the Chattahoochie river, about 18 miles northeast from where the railroad from Chattanooga to Atlanta crosses the Chattahoochie river. It is about 15 miles due east from Marietta, and is in a very broken, almost mountainous region—the southern slope of the Apalachian chain."

From Professor John C. Cresson, Philadelphia, May 23, 1866.

During a brief thunder-shower on Sunday, May 13th, at 4½ p. m., an electric discharge occurred at Franklin square, in this city, under the following circumstances:

A small elm tree, about 40 feet high, standing about 190 feet south of a flag-staff 150 feet high, was injured, and the bark torn from its southeast side for a length of 20 feet. A splinter of sapwood two inches wide, one inch thick, and about 20 feet long, was ripped out on the southeast side and scattered in minute shreds.

This injury does not reach the base of the tree nor its topmost branches. This tree is surrounded by several others, not more than 20 feet distant and several feet higher, none of which are injured. At the distance of 12 feet nearly east of the injured tree is an iron lamp-post, with a gas-pipe protruding at its top, nine feet from the ground.

The thunder-cloud approached from the southwest, and the manner of the occurrence seems to be thus: When the charged cloud came nearly over the lamp-post and gas-pipe, the latter formed a prominent conductor, and by making an open way for inductive action, determined the time and line of discharge. The line was along the southeast side of the injured tree, and near enough to cause the injury by violent disturbance of electrical equilibrium along and around its path. Thinking the facts may be deemed worthy of record, I venture to send this statement, and cannot forbear to accompany it with my notion of the mode of action.

From Henry Haas, Depauville, Jefferson County, New York, April 20, 1867.

About sunset on the 20th of April, during the thunder-storm, an electric discharge struck the dwelling of J. Edmunds, entering through the open front door, knocking the wooden blocks from under the legs of a cooking-stove, without upsetting the stove, then passing across the room into an adjoining apartment and out at the window, breaking a number of lights, doing no other injury to the building. Three persons sat around the stove at the moment the electric fluid entered the house; they were more or less stunned, but all escaped unhurt.

From H. J. Kron, Albemarle, North Carolina, April 24, 1867.

At Attaway Hill, Stanly county, North Carolina, there was a heavy thunder-storm from the southeast during the night of the 24th of April, commencing at about 11 o'clock. There was a rapid succession of thunder and lightning, with beating rain and hail of small size, but no damage done. At the distance of about a mile the lightning struck the lowest of two pines some nine feet apart.

The long spiral track from the summit down ended within a foot of the ground, which latter was neither perforated nor ploughed up.

[Probably in this case the electricity was carried off by a temporary flood of water over the ground at the foot of the tree.—J. H.]

FROM PROFESSOR B. F. MUDGE, MANHATTAN, KANSAS, JUNE 15, 1867.

At 7 a. m. the lightning struck the house of William Higinbothom, in Manhattan, Kansas, (two miles from the college,) and severed the lightning-rod at every connection or joint, without damage to the house. The rod was $\frac{5}{8}$-inch iron. The connections were made by a brass nut screwed on to the ends of each section. The brass nuts were in some cases melted. The point, to the length of half an inch, which was of copper plated with silver, was also melted. When the fluid reached the eaves of the house it parted, and one portion followed the tin gutter-spout round the house, turning eight square corners (right angles.) At each angle the tin was burned or melted.

[In all cases of an electrical discharge a repulsive energy is evolved in the direction of the axis of the conductor, tending to break it by a transverse fracture.—J. H.]

FROM THE NEW HAVEN (CONNECTICUT) JOURNAL.

On the 20th of June, 1867, the lightning struck the house of Mrs. R. M. Page, on the corner of Pleasant and Humphrey streets. The bolt, as it neared the house, divided, one part striking the roof near the west chimney, and passed through the roof, tearing up the tin roofing in such a way that it looks as if it had been forced off from the inside. The fluid passed into the attic, striking the chimney near the roof, and gouging out a large hole in it, and then passed out of the attic window, making two holes through one of the panes, as if two small cannon-balls had been shot through it. After passing through the window there were no further signs of its course. The attic room was thoroughly shattered, and the ceiling splintered into a thousand fragments. The other branch of the bolt struck the east chimney, knocking off a good portion of it. It passed down through the roof to the attic floor, and passed out of the room at the southeast corner, and ran down the water-pipe to the ground, shattering the earthen tile drain that conducts the water to the cistern. From here it passed through the corner of the house, following a nail, coming out near a water-pail with copper hoops, that stood near the sink. It completely demolished the pail, and seemed to have spent its force in doing so. Under the attic room, on this side of the house, was a closet, the lath and plaster of which were torn off. Some of the plastering was thrown across the chamber and struck the headboard of the bed with such force as to stick fast. Under the pillow of the bed was found a nail that was so hot when thrown there that it burned the sheets. A woman who had just closed the basement window and crossed the room when the stroke entered at the sink, was thrown prostrate, and was much stunned and deafened for awhile; and her husband, who was sitting in the room alone with his child, was also considerably shocked. Persons who were in the street near the house at the time were also stunned, and had to grasp hold of the fence to keep from falling.

FROM DR. SAMUEL D. MARTIN, NEAR CHILESBURG, KENTUCKY, OCTOBER 27, 1867.

I to-day saw for the first time a tree that had been struck with lightning, probably in July. It was a white ash, about two feet in diameter, and stood in a woodland pasture, about half a mile east from my house. The appearance indicated a remarkable power in the discharge. The tree was split up into pieces

about as large as common fence-rails, which formed a circle around the stump 180 feet in diameter. One of these rails is 30 feet long, another 27, and most of the others about 12 feet long. There were a great number of splinters, three or four feet long, cast outside the circle.

[The remarkable energy exhibited in this case, as in others of a similar character, is probably due to the sudden conversion of the sap into highly elastic vapor.—J. H.]

FROM G. WRIGHT, STERLING, WHITESIDE COUNTY, ILLINOIS, DECEMBER 5, 1867.

As I always watch the approach of storms with great interest, I was, in this instance, well repaid for my trouble. The heavy mass of clouds in the southwest gradually raised, so that the lower edge was distinctly marked upon the falling rain, as is usual in sudden storms. But I observed to those near me that I never before saw the line so clearly defined and so regular; but suddenly a large mass began to protrude from the rounded outline and approach the earth in the form of a cone, with the apex towards the earth. As we live on the line of the great tornado, some of my family apprehended the cloud was taking the fearful shape, but as it rapidly approached the earth a vivid flash darted from the lower point, which was still rounded, and the whole mass was quickly drawn up into line again. This was repeated as the shower approached, until the cone descended from the same part of the cloud three times, and then, as it began to rain where we were, the outline of the cloud was lost to view. I cannot describe to you the sensation which I felt as the great mass of dark clouds fell with increasing velocity toward the earth, but it was much like that which one experiences in rolling a large stone from the edge of a precipice. The display was so grand that it will never be forgotten by those who saw it.

[An account of a precisely similar phenomenon is given in a letter to Dr. Hare, from Z. Allen, of Providence, published in the Transactions of the American Philosophical Society. The facts are interesting in relation to the connection of electricity with tornadoes, of which the descending cone was probably an incipient one.—J. H.]

FROM CHARLES C. BOERNER, VEVAY, INDIANA, MAY 26, 1868.

May 26, 11 p. m., to 27th, 1 a. m.—Thunder-storm of uncommon violence from the southeast; wind from the same direction. It was preceded by a strong gale of 15 minutes' duration; lightning zigzag. The storm raged for 30 minutes, after which it somewhat abated, and apparently passed away, when suddenly, at 12 o'clock, a heavy discharge of electricity, accompanied by a terrific explosion, seemed to startle all nature. In the morning I ascertained that it struck near the market-place; the object was a rack placed there for the hitching of horses. The rack is about 40 feet long, and upon posts (locust) three feet from the ground; on the top rail are 25 iron rings, fastened with staples, and the rails themselves fastened to the posts with heavy iron clamps. This top rail was entirely thrown off, and the posts shattered into splinters; some of them were scattered in different directions more than 75 feet. The most remarkable fact is that the place is surrounded by high buildings, all of which escaped destruction. Northwest, 75 feet from the place struck, stands a brick building, covered with metallic roof, 75 feet high; southward the open market-place; southeast the market-house, 40 feet high; and northeast, at a distance of 125 feet, a row of two-story brick buildings. None of these are supplied with lightning conductors.

[Electricity, in its discharge from the clouds to the earth, frequently appears very capricious; but in all cases the discharge is, as it were, predetermined by the

line of greatest attraction and least resistance, conditions which cannot, in all cases, be ascertained, even with a minute examination of all the objects, since active attracting materials frequently exist beneath the surface of the earth.—J. H.]

FROM W. S. GILMAN.

One of the most beautiful electrical phenomena imaginable was witnessed on the evening of the 9th January, 1868, in the office of the Atlantic and Pacific telegraph line, Rochester, New York. Wire No. 1 of this line was down between this city and Syracuse. Suddenly it was discovered that neither wire would work. A continuous current of electricity was then observed to be passing over the wires and through the several instruments, and this while the batteries were detached. The current seemed to be of the volume of a medium-sized pipe-stem, and exhibited the several colors of the rainbow. With the key open the current flowed in waves or undulations, and from the surcharged wire it leaped over the insulated portions of the key and passed along the wires beyond. The same phenomenon was observed at Buffalo and at Cleveland. The gas in the office was lighted without difficulty by holding the end of a wire within an inch or two of the gas-burner. The current was intense enough to shock one holding the wires or instruments; indeed, one of the employés of the office had his fingers scorched by the current. With closed keys the current was continuous, as before stated.

This phenomenon has never been witnessed except when cold weather prevails extensively. The broken wire spoken of, which rested on the ground, was the point of communication with the earth.

Here we may notice one thing not generally known. A portion of a speech of Hon. William H. Seward in Rochester, a few years since, was telegraphed to New York and from Boston to Portland by the electrical influences of the aurora borealis, all the batteries on the line being detached. This feat, it is said, has never been repeated.

The following additional information was furnished in answer to inquires by the Institution:

The questions you put with reference to the Rochester electrical phenomena are thus answered:

1. Whether any appearance of the aurora was visible at the time? I learn of none; sky clouded at Rochester, Toronto, and Montreal, and storming.

2. Whether the discharges were continuous or fitful? From B. F. Blackall, manager of the Atlantic and Pacific Telegraph Company, Rochester, I learn as follows: At 4.30 p. m. trouble commenced while he was "transmitting a telegram to New York over the No. 1 wire, which was afterwards located between Fulton and Syracuse, one wire being broken, and the western end hanging across No. 2, rested on the ground. At the same instant I noticed my relay surcharged with an unusual amount of magnetism. Upon opening my key, which we usually give the sixteenth of an inch play, discharges of electricity, averaging as high as 300 pulsations a minute from one platina point to the other, and the nearer I placed these points the more rapid they occurred. * * * * The fluid was passing from west to east through the key. In addition there was a current about the size of a pin flowing from the core of the helices to the soft piece of iron on the armature, which sounded very much like electricity produced by friction on a glass cylinder when passing to a Leyden jar." The phenomenon continued until about 7 p. m. The writer informs me that he has witnessed a half dozen similar but weaker displays during the past 14 years, and always between 4 p. m. and 7 p. m.

From C. W. Dean, manager of the same line, Cleveland, Ohio, I learn as follows: An extraneous current made it impossible to work the wire on January 9th last. It was first noticed at 9 a. m., when the current grew so strong that

"the No. 1 wire was opened to Painesville, 30 miles east. This did not help it in the least. I judged that our wires were crossed with those of Western Union lines, and that we were getting the full strength of their 100 cups of battery. One thing very strange was that the current pulsated, and the armature of the magnet disconnected from the battery and the wire open east vibrated like a pendulum."

From J. A. Osborne, Buffalo, New York, connected with the same line, I learn that the wires of their office were so heavily charged that he thought certainly they were crossed with the Western Union wires. The wires could not be touched. The current passed over in waves, and it was necessary to throw the instruments out of circuit in order to prevent damage to them. Fantastic streaks flashed across the wires. At one time a continuous stream of fire passed off, which lasted from four to five seconds. Had the current been more steady the wires could have been worked without the aid of the batteries. At Lockport the electricity set fire to a board to which the wires were attached. The magnets became so surcharged with electricity that when the wires were disconnected the armature remained drawn up to the coils for full three-quarters of an hour.

3. Whether some time elapsed between each discharge, as if the conductor was gradually charged? This question is answered in the above extracts from letters received by me from the different operators.

[On the night in question an aurora is noticed in the Smithsonian records at Independence, Iowa, and a heavy snow in Michigan. A wave of low temperature was passing from the west to the east from the 7th to the 10th of January, reaching its minimum in the State of New York on the night of the 9th and morning of the 10th. The phenomenon may perhaps have been due to the falling of the snow on a western portion of the line. The ascending vapor from which this snow was produced would become negatively electrified by induction from the plus electricity of the space above. In the subsequent freezing of this vapor into snow, it would retain its electrical condition, and falling on the wire would give the latter a charge of negative electricity which would be propagated by conduction both east and west.—J. H.]

QUERIES ABOUT EXPRESSION FOR ANTHROPOLOGICAL INQUIRY.

By Charles Darwin, of Down, Bromley, Kent, England.

1. Is astonishment expressed by the eyes and mouth being opened wide, and by the eyebrows being raised?

2. Does shame excite a blush when the color of the skin allows it to be visible?

3. When a man is indignant or defiant does he frown, hold his body and head erect, square his shoulders, and clench his fists?

4. When considering deeply on any subject, or trying to understand any puzzle, does he frown or wrinkle the skin beneath the lower eyelids?

5. When in low spirits, are the corners of the mouth depressed, and the inner corner or angle of the eyebrows raised by that muscle which the French call the "grief muscle?"

6. When in good spirits do the eyes sparkle, with the skin around and under them a little wrinkled, and with the corners of the mouth a little drawn back?

7. When a man sneers or snarls at another, is the corner of the upper lip over the canine teeth raised on the side facing the man whom he addresses?

8. Can a dogged or obstinate expression be recognized, which is chiefly shown by the mouth being firmly closed, a lowering brow, and a slight frown?

9. Is contempt expressed by a slight protrusion of the lips and turning up of the nose, with a slight expiration?

10. Is disgust shown by the lower lip being turned down, the upper lip slightly raised, with a sudden expiration something like incipient vomiting?

11. Is extreme fear expressed in the same general manner as with Europeans?

12. Is laughter ever carried to such an extreme as to bring tears into the eyes?

13. When a man wishes to show that he cannot prevent something being done, or cannot himself do something, does he shrug his shoulders, turn inwards his elbows, extend outwards his hands, and open the palms?

14. Do the children, when sulky, pout, or greatly protrude the lips?

15. Can guilty, or sly, or jealous expressions be recognized? though I know not how these can be defined.

16. As a sign to keep silent, is a gentle hiss uttered?

17. Is the head nodded vertically in affirmation and shaken laterally in negation?

Observations on natives who have had little communication with Europeans would be, of course, the most valuable, though those made on any natives would be of much interest.

General remarks on expression are of comparatively little value. A definite description of the countenance under any emotion or frame of mind would possess much more value.

An answer to any *single* one of the foregoing questions would be gratefully accepted.

Memory is so deceptive on subjects like these that I hope it may not be trusted to.

ON THE VARIOUS MODES OF FLIGHT IN RELATION TO AERONAUTICS.

By Dr. James Bell Pettigrew.

[FROM THE PROCEEDINGS OF THE ROYAL INSTITUTION OF GREAT BRITAIN.]

The subject of flight, natural and artificial, is one which has occupied the attention of mankind from a very early period.

It involves a more or less intimate acquaintance with anatomy, physiology, mechanics, and the higher branches of mathematics.

If regarded as a natural movement, it forms one of the three kinds of locomotion by which animals progress—the remaining two being walking and swimming; if regarded as an artificial one, it represents the unsolved problem of that grand trio which has for its integral parts the locomotive, steamboat, and flying machine. Had time permitted, it was my intention to have gone into the subject of locomotion at length. I find, however, I must curtail my remarks under this head, which I do with reluctance, from a feeling that the chain of animal movements, like the great chain of existence, winds in and out and doubles upon itself so completely as to render a partial examination of it in many respects unsatisfactory.

The movements of animals are adapted either to the earth, the water, or the air. There are others, however, of a mixed character, where they are suited equally to the land and water, or even to the land, water, and air.

The instruments by which locomotion is attained are therefore specially modified.

This is necessary because of the different densities and the different degrees of resistance furnished by the land, water, and air respectively.

As the earth affords a greater amount of support than the water, and the water than the air, it requires a greater degree of muscular exertion to swim than to walk, and a still greater one to fly.

For this reason flight is the most laborious, and in some respects the most complicated and difficult, of all the animal movements.

The peculiarities of the different media, as far as locomotion is concerned, may be briefly stated.

On the land we have the maximum of resistance and the minimum of displacement.

In the air, the minimum of resistance and the maximum of displacement.

The water is intermediate in these respects.

As a consequence, the feet of land animals are small—their bodies large. The horse and deer furnish examples.

In those land animals which take to the water occasionally, or the reverse, the feet are enlarged and usually provided with a membranous expansion between the toes. Of such, the otter, ornithorhynchus, seal, frog, turtle and crocodile may be cited.

In addition to the land animals which run and swim, there are some which precipitate themselves, parachute fashion, from immense heights, and others which even fly. In these the membranous expansions are greatly increased—

the ribs affording the necessary degree of support in the dragon or flying lizard, the anterior and posterior extremities in the flying lemur, flying cat, and bat.

Although no lizard is at present known to fly, there can be little doubt that the extinct pterodactyles, which are intermediate between the lizards and crocodiles, were possessed of this power.

The bat is interesting as being the only mammal at present enjoying the privilege of flight; it is likewise instructive, as showing that flight may be attained without the aid of hollow bones and air-sacs, by purely muscular efforts and by the mere contraction and dilatation of a continuous membrane.

If we now direct our attention to the water we find that the amount of surface engaged in locomotion greatly exceeds that in the amphibia. The fish furnishes the best example.

In it the lower half of the body and the broadly-expanded tail are applied to the water very much as an oar is in sculling. The sea-mammals, as the whale, dugong, manatee, and porpoise, swim in precisely the same manner as the fish, with this difference, that the tail strikes from above downwards, or vertically instead of horizontally, or from side to side. The seal is exceptional in this respect.

The animals which furnish the connecting link between the water and the air are the flying fishes on the one hand, and the diving birds on the other; the former sustaining themselves for considerable intervals in the air by means of their enormous pectoral fins, the latter using their wings for flying above and beneath the water, as occasion demands.

I have carefully examined the relations, structure, and action of the fins in the flying-fish, and am of opinion that they act as true pinions; their inadequate dimensions only preventing them from sustaining the fish for an indefinite period in the air, at all events so long as they remain moist. They operate upon the air from beneath, after the manner of a kite or spiralifer, and in so doing, lever the animal upwards and forwards.

If they did not act as true pinions within certain limits it is difficult and indeed impossible to understand how such small creatures could obtain the momentum necessary to project them a distance of 200 or more yards, and that sometimes at an elevation of 20 feet above the water.

In birds which fly indiscriminately above and beneath the water, the wing is generally provided with stiffer feathers than usual, and reduced to a minimum as regards size. In subaqueous flight the wings may act by themselves, as in the guillemots, or in conjunction with the feet, as in the grebes; but in either case it is the back or convex surface of the wing which gives the effective stroke, the wing in such birds as the great auk, which are incapable of flight, being for this purpose twisted completely round, in order that its concave surface, which takes a better hold of the water, may be directed backwards.

The wing, therefore, operates very differently in and out of the water.

In the water it acts as an auxiliary of the foot, and both strike backwards and downwards.

In the air, on the contrary, it strikes *downwards and forwards*, and this is a point deserving of attention, as showing that the oblique surfaces presented by animals to the water and air are made to act in opposite directions. This is owing to the greater density of the water as compared with the air; the former supporting or nearly supporting the animal acting upon it; the latter permitting the animal to fall through it in a downward direction.

But to come to the subject more particularly in hand, viz:

Flight in its relation to Aeronautics.—The atmosphere, because of its great tenuity, mobility, and comparative imponderability, presents little resistance to bodies passing through it at low velocity. If, however, the speed be greatly increased, the action of even an ordinary cane is sufficient to elicit a recoil.

This comes of the action and reaction of matter, the resistance experienced

varying according to the density of the atmosphere and the shape, extent, and velocity of the body acting upon it. While, therefore, almost no impediment is offered to the progress of an animal in motion, it is often exceedingly difficult to compress the air with sufficient rapidity and energy to convert it into a suitable fulcrum for securing the onward impetus. This arises from the fact that bodies moving in this medium experience the minimum of resistance and occasion the maximum of displacement. Another and very obvious difficulty is traceable to the great disparity in the weight of air as compared with any known solid, (this in the case of water being nearly as 1,000 to 1,) and the consequent want of buoying or sustaining power which that disparity necessitates. To meet these peculiarities the insect and bird are furnished with extensive surfaces in the shape of pinions or wings, which they can apply with singular velocity and power at various angles, or by alternate slow and sudden movements, to obtain the necessary degree of resistance and non-resistance. Their bodies, moreover, are constructed on strictly mechanical principles—lightness, strength, and durability of frame; and power, rapidity, and precision of action being indispensable. The cylindrical method of construction is consequently carried to an extreme; the bodies and legs of insects displaying numerous unoccupied spaces, while the muscles and solid parts are tunnelled in every direction by innumerable air tubes which communicate with the surrounding medium by a series of apertures termed spiracles.

A somewhat similar disposition of parts is met with in birds, these being in many cases furnished not only with hollow bones, but also (especially the aquatic ones) with a liberal supply of air-sacs. They are also provided with a dense covering of feathers or down, which adds greatly to their bulk without materially increasing their weight. The air-sacs are well seen in the swan, goose, and duck; and I have in several instances carefully examined them with a view to determining their extent and function. They appear to me to be connected with the function of respiration, a view advocated by Hunter in 1774, and within the last year or so by Drosier, of Cambridge. That they have nothing whatever to do with flight is proved by the fact that some excellent flyers—take the bats *e. g.*—are destitute of them, while the wingless running birds, such as the ostrich, and apteryx, which are incapable of flight, are provided with them. The same may be said of the hollow bones, some really admirable flyers, as the swallows, martins, and snipes, having their bones filled with medullary substance, while the bones of the running wingless birds alluded to are filled with air. Furthermore, and finally, a living bird weighing 10 pounds weighs the same when dead minus a very few grains; and all know what effect a few grains of heated air would have in raising a weight of 10 pounds from the ground.

When we have said that cylinders and hollow chambers increase the area of the insect and bird, and that an insect and bird so constructed is stronger, weight for weight, than one composed of solid matter, we may dismiss the subject; flight being, as I shall endeavor to show by-and-by, not so much one of weight as of power properly directed, *i. e.* power directed on strictly mechanical principles. Those who subscribe to the heated-air theory are of opinion that the air contained in the cavities of insects and birds is so much lighter than the surrounding atmosphere, that it must of necessity contribute materially to flight; but the quantity of air imprisoned is, to begin with, so infinitesimally small and the difference in weight which it experiences by increase of temperature so inappreciable, that it ought not to be taken into account by any one endeavoring to solve the difficult and important problem of flight. The Montgolfier or fire-balloons were constructed on the heated-air principle; but as these have no analogue in nature, and are apparently incapable of improvement, they need not detain us at this stage of the inquiry. The area of the insect and bird when the wings are fully expanded is, with the single exception of the bats, greater

than that of any other class of animals, their weight being proportionably less. It ought, however, never to be forgotten that even the lightest insect or bird is immeasurably heavier than the air, and that there is no fixed relation between the weight of body and the expanse of wing in either class. We have thus light-bodied and large-winged insects and birds, as the butterfly, heron, and albatross; and others, whose bodies are comparatively heavy, while their wings are insignificantly small, as in the sphinx-moth and stag-beetle among insects, and the grebe, quail, and partridge among birds. Those apparent inconsistencies are readily explained by the greater muscular development of the heavy-bodied, short-winged insects and birds, and the increased power and rapidity with which the wing is made to oscillate. This is of the utmost importance in the science of ærostation, as showing that flight may be attained by a heavy, powerful animal with comparatively small wings, as well as by a lighter one with enormously enlarged wings. While, therefore, there is apparently no correspondence between the area of the wing and the animal to be raised, there is an unvarying relation as to the weight and number of oscillations, so that the problem of flight seems to resolve itself into one of weight, power, velocity, and small surfaces; *versus* buoyancy, debility, diminished speed, and extensive surfaces; weight in either case being a *sine qua non.*

In order to utilize the air as a means of transit, the body in motion, whether it moves in virtue of the life it possesses, or because of a force superadded, must be heavier than it. If it were otherwise, if it were rescued from the operation of gravity on the one hand, and bereft of independent movement on the other, it must float about uncontrolled and uncontrollable, as happens in the ordinary gas balloon. The difference between an insect or bird and a balloon here insisted upon was, I have learned since writing the above, likewise pointed out by his grace the Duke of Argyll, in his very able and eloquent article in Good Words, entitled "The Reign of Law"*—an article whose merits cannot be too widely acknowledged or too universally known. The wings of insects and birds are, as a rule, more or less triangular in shape, the base of the triangle being directed towards the body, the sides anteriorly and posteriorly. They are also conical on sections from within outwards and from before backwards, this shape converting the pinion into a delicately-graduated instrument, balanced with the utmost nicety to satisfy the requirements of the muscular system on the one hand, and the resistance and resiliency of the air on the other. While all wings are graduated as explained, innumerable varieties occur as to their general contour, some being falcated or scythe-like, others oblong, others rounded or circular, some lanceolate, and some linear.

Wing of insect.—The wings of insects may consist either of one or two pairs; the anterior or upper pair, when two are present, being in some instances greatly modified and presenting a corneous condition. When so modified they cover the under wings when the insect is reposing, and have from this circumstance been named elytra from the Greek ἔλυτρον, a sheath. The elytra or wing-cases, as they are sometimes called, are dense, rigid, and opaque in the beetles; solid in one part and membranous in another in the cockroaches; more or less membranous throughout in the grasshoppers; and completely membranous in the dragon-flies. The superior or upper wings are indirectly connected with flight in the beetles, cockroaches, and grasshoppers, and actively engaged in this function in the dragon-flies and butterflies. The true wings, and by this I mean the membranous ones, present different degrees of opacity; those of the moths and butterflies being non-transparent; those of the dragon-flies, bees, and common flies presenting a delicate, filmy, gossamer-like appearance. They have, however, this feature in common, and it is fundamental: both pairs are composed of

* Good Words for February, 1865. This article I am glad to find has been reprinted in a separate form with numerous illustrations, and should be read by all interested in the subject of æronautics. (J. B. P.)

a duplicature of integument, or investing membrane, and are strengthened in various directions by a system of hollow, horny tubes, known to entomologists as the neuræ or nervures. These nervures taper towards the extremity of the wing, and are strongest towards its root and anterior margin, where they supply the place of the arm in bats and birds.

The neuræ are arranged at the axis of the wing after the manner of a fan or spiral stair; the anterior one occupying a higher position than that further back, and so of the others. As this arrangement extends also to the margins, the wings are more or less twisted upon themselves, and present a certain degree of convexity upon their superior or upper surface, and a corresponding concavity on their inferior or under surface; their free edges supplying these fine curves which act with such efficacy upon the air in obtaining the maximum of resistance and the minimum of displacement. As illustrative examples of the form of wing alluded to, that of the beetle, bee, and fly may be cited; the pinion in those insects acting as helices, or twisted levers and elevating weights, much greater than the area of the wing would seem to warrant. The insects adverted to fly, as a rule, with great accuracy and speed, and frequently in a straight line.

From the foregoing account it is evident that the wings of insects vary as regards their number, size, and shape. They also differ as regards their surfaces, margins, venation, degree of consistence and position, so that it might naturally be asked, Do the several orders of wings act according to a common principle, or does each wing act according to a principle of its own? There can, I think, be but one answer to this question. All wings obtain their leverage by presenting oblique surfaces to the air, the degree of obliquity gradually increasing in a direction from behind, forwards and downwards, during extension when the sudden or effective stroke is being given, and gradually decreasing in an opposite direction during flexion, or when the wing is being more slowly recovered preparatory to making a second stroke. The effective stroke in insects—and this holds true also of birds—is therefore delivered *downwards and forwards*, and not, as the majority of writers believe, vertically, or even slightly backwards. This arises from the curious circumstance, that insects and birds when flying actually fall through the medium which elevates them, their course being indicated by the resultant of two forces, viz: that of gravity, pulling vertically downwards, and that of the wing, acting at a given angle in an upward direction. The wing of the bird acts after the manner of a boy's kite, the only difference being that the kite is *pulled forward* upon the wind by the string and the hand, whereas in the bird the wing is *pushed forward* on the wind by the weight of the body and the life residing in the pinion itself. The angle at which the wing acts most efficaciously as an elevator, as proved by an examination of the pinion of the living insect, bat, and bird, when fully extended and ready to give the effective stroke, is an angle of 45° with the horizon. As, however, this angle could not be uniformly maintained without a rotary motion which would wrench the wings from their fixings, a compromise is adopted, the wing being made to rotate on its axis to the extent of a quarter of a turn in one direction during extension, and the same amount in an opposite direction during flexion. That the wing rotates upon its axis as explained may be readily ascertained by watching the movement in the larger domestic fly. If the insect be contemplated either from above or beneath, the blur presented by the rapidly oscillating wing will be found to be concave, the depressed portion representing the wing when its plane of least resistance is parallel with the plane of progression. Of this I have had the most convincing proof, particularly in semi-torpid insects where the wing was plied with less vigor than usual. To confer on the wing the multiplicity of movement which it requires, it is supplied with a double hinge or compound joint which enables it to move not only in an upward, downward, forward, and backward direction, but also at various intermediate degrees of obliquity. An insect furnished with wings thus hinged may, as far as steadi-

ness of body is concerned, be not inaptly compared to a compass set upon gimbals, where the universality of motion in one direction insures comparative fixedness in another.

Many instances might be quoted of the marvellous powers of flight residing in insects as a class. The male of the silkworm moth (Attacus Paphia) is stated to travel more than 100 miles a day;* and an anonymous writer in Nicholson's Journal calculates that the common house fly (Musca domesticus) in ordinary flight makes 600 strokes per second, and advances 25 feet; but that the rate of speed, if the insect be alarmed, may be increased six or seven fold, so that under certain circumstances it can outstrip the fleetest race-horse. Leeuwenhoek relates a most exciting chase which he once beheld in a menagerie about 100 feet long, between a swallow and a dragon fly (mordella.) The insect flew with such incredible speed and wheeled with such address that the swallow, notwithstanding its utmost efforts, completely failed to overtake it.†

Wing of bird.—There are few things in nature more admirably constructed and where design can be more readily traced than in the wing of the bird. Its great strength and extreme lightness, the manner in which it closes up or folds during flexion, and opens out or expands during extension, as well as the method according to which the feathers are strung together, and slate each other in divers directions to produce at one time a solid resisting surface, and at another an interrupted and comparatively non-resisting one, present a degree of fitness to which the mind must necessarily revert with pleasure. The wing of the bird, like that of the insect, is concavo-convex, and more or less twisted upon itself when extended, so that the upper or thick margin of the pinion presents a different degree of curvature to that of the nether or thin margin, the curves of the two margins in some instances even intersecting each other. This twisting is in a great measure owing to the manner in which the bones of the wing are twisted upon themselves, and the spiral nature of their articular surfaces, the long axes of the joints always intersecting each other at right angles. As a result of this disposition of the articular surfaces the wing may be shot out or extended, and retracted or flexed in nearly the same plane, the bones composing the wing rotating on their axes during either movement. This secondary action, or the revolving of the component bones upon their own axes, is of the greatest importance in the movements of the wings, as it communicates to the hand and forearm, and consequently to the primary and secondary feathers which they bear, the precise angles necessary for flight. It in fact insures that the wing, and the curtain or fringe of the wing which the primary and secondary feathers form, shall be screwed into and down upon the wind in extension, and unscrewed or withdrawn from the wind during flexion. The wing of the bird may, therefore, be compared to a huge gimlet or auger, the axis of the gimlet representing the bones of the wing, the flanges or spiral thread of the gimlet the primary and secondary feathers. As the degree of rotation made by the bones of the forearm and hand during extension amounts as nearly as may be to a quarter of a turn of a spiral, it follows that in flexion the wing presents a knife-like edge to the wind; whereas in extension the curtain of the wing is rotated in a downward direction until its anterior or concave surface makes an angle of 45° with the horizon. From this description it will be evident that by the mere rotation of the bones of the forearm and hand the maximum and minimum of resistance is secured much in the same way that this object is attained by the alternate dipping and feathering of an oar.

In the majority of quick-flying birds—at all events in such as do not glide or skim—considerable advantage is gained by the primary and secondary feathers being thrown out of position during flexion, this arrangement preventing retard-

* Linn. Trans, vii, 40.

† The hobby falcon which abounds in Bulgaria is equal to this task, the dragon-fly forming a principal constituent of its food.

ation, by diminishing the amount of air displaced. This slating or overlapping and unslating action of the feathers during extension and flexion is, however, one of the peculiarities or refinements, and not necessarily an essential in flight, as this function can be efficiently performed by the insect and bat where no feathers are present, and where consequently no opening or closing of them can possibly occur. The wing of the bird may be said to act in three different ways: 1st, during extension, when it gradually makes an angle of 45° with the horizon; 2d, during the downward stroke, when it maintains the angle of 45° with the horizon, and makes a variable angle with the body; and 3d, during flexion, when it acts at a gradually decreasing angle in virtue of its being carried against the wind by the body of the bird which is in motion; it being a matter of indifference whether the wing acts on the air or the air on the wing, so long as the body bearing the latter is under way; and this is perhaps the chief reason why the albatross, which is a very heavy bird,* can sail about for such incredible periods without apparently moving the wings at all. Captain Hutton thus graphically describes the sailing of this magnificent bird: "The flight of the albatross is truly majestic, as with outstretched motionless wings he sails over the surface of the sea, now rising high in air; now, with a bold sweep and wings *inclined at an angle* with the horizon, descending until the tip of the lower one all but touches the crest of the waves as he skims over them."†

"Tranquil its spirit seemed, and floated slow,
Even in its very motion there was rest."

As an antithesis to the apparently lifeless wings of the albatross, the ceaseless activity of those of the humming bird might be adduced. "In those delicate and exquisitely beautiful birds, the wings, according to Mr. Gould, move so rapidly when the bird is poised before an object that it is impossible for the eye to follow each stroke, and a hazy circle of indistinctness on each side of the bird is all that is perceptible."

The various movements involved in ascending, descending, wheeling, gliding and progressing horizontally are all the result of muscular power, properly directed and acting upon appropriate surfaces—that apparent buoyancy in birds, which we so highly esteem, arising not from superior lightness but from their possessing that degree of weight which enables them to subjugate the air; weight and independent motion being the two things indispensable in successful aerial progression. The weight in insects and birds is in great measure owing to their greatly-developed muscular system—this being in that delicate state of tonacity which enables them to act through its instrumentality with marvellous dexterity and power, and to expend or reserve their energies, which they can do with the utmost exactitude in their lengthened and laborious flights. The elastic structures which receive or draw back the wing in the insect and bird during flexion are of the utmost consequence in the movements of the wings; these, by their mere contraction, enabling the muscles of the wing to rest nearly half the time they are in action. In this we have a probable explanation of the extraordinary power of endurance displayed by insects and birds on the wing.

The foregoing remarks on the wings of insects and birds lead me to speak of the inclined plane as applied to the air, but before doing so it will be advisable to allude briefly to the balloon.

Balloon.—This, as my audience is aware, is constructed on the obvious principle that a machine lighter than the air must necessarily rise through it. The Montgolfier brothers invented such a machine in 1782. Their balloon consisted of a paper globe or cylinder, the motor power being superheated air supplied by

* The average weight of the albatross, as given by Gould, is 17 pounds. "Ibis," 2d series, vol. i, 1865, p. 295.

The Pelicanus onocrotalius weighs 25 pounds. Roget's Bird's Journal, vol. i, p. 490.

† On some of the birds inhabiting the Southern ocean, by Captain W. F. Hutton. "Ibis," 2d series, vol. i, 1865, p. 282.

the burning of vine twigs under it. The Montgolfier or fire balloons, as they were called, were superseded by the hydrogen-gas balloon of MM. Charles and Robert, this being, in turn, supplanted by the ordinary gas balloon of Mr. Green. Since the introduction of coal gas in the place of hydrogen gas no radical improvement has been effected; all attempts at guiding balloons have signally failed. This arises from the vast extent of surface which they necessarily present, rendering them a fair conquest to every breeze that blows; and because the power which animates them is a mere lifting power which, in the absence of wind, must act in a vertical line, all other motion being extraneous and foreign to it. It consequently rises through the air in opposition to the law of gravity, very much as a dead bird would fall in a downward direction in accordance with it. Having no hold upon the air, this cannot be employed as a fulcrum for regulating its movements, and hence the cardinal difficulty in ballooning as an art.

Any one attempting to control the movements of a balloon is very much in the position of a boatman who endeavors to steer his craft, which is drifting with the current, by pushing against the stern.

If ever the balloon is to be utilized as a means of transit, this will probably be achieved by converting part of its lifting power into a horizontal propelling power, which possibly could be done by affixing a horizontal screw, like a small windmill, to the car; this apparatus receiving its motion by being forced against the air from beneath during its ascent, (the air playing upon it from above,) and communicating its movements to a similar and smaller screw placed vertically or at right angles, which could be made to revolve with great celerity as a driving screw. To prevent rotation in the balloon itself, it might be armed with plates of some light material placed at right angles to the plane of rotation. The great expense, however, involved in the construction and filling of the balloon will always operate against its being used otherwise than as a luxury; while the enormous expanse and delicacy of the material employed, as well as the change in volume of the contained gas arising from increase or decrease of temperature, cannot fail to prove troublesome, not to say dangerous.

Finding that no marked improvement has been made in the balloon since its introduction in 1782, we naturally turn our attention to some other method of traversing the air; and here I would add my independent testimony in favor of the helice or screw, not only as a lifting power, but also as a propelling power. When I commenced my inquires into the structure and the uses of wings, I was early struck with the curious manner in which they are twisted upon themselves, and how they are rotated on and off the wind during flexion and extension, after the manner of screws; and without knowing (for the subject of artificial flight is not much in my way) that the helice had been proposed as a means for raising inanimate bodies, I had actually constructed a double screw, with a view to testing its efficacy in this respect.* I have therefore unwittingly laid anatomy and physiology under contribution in support of what I find is not a new doctrine.† I was impelled in this direction by detecting the principle in nature, and from knowing that a body to rise and progress in the air need not necessarily be lighter than it; in fact, that the balloon is constructed on a principle diametrically opposed to that on which the bat, insect, and bird are constructed, and is from this circumstance open to serious, and in some respects, insuperable objections.

The efficacy of the screw in water is well known, and the action of the child's toy, usually called the spiralifer, will illustrate its utility as applied to the air. This toy, for toy it has hitherto been, consists of two inclined planes, produced

* This screw had four fans or blades, two of which revolved from left to right; the remaining two from right to left This I found to be necessary to prevent rotation in the driving apparatus, which consisted of a steel spring and clockwork.

† Paucton, the engineer, predicted the future importance of the screw in aerial navigation.

by simply twisting the enveloping wires in opposite directions. It therefore represents the most primitive form of screw. This apparatus, simple as it may appear, curiously enough furnishes the mechanical appliance by which a body may be elevated, or elevated and carried in a horizontal direction at one and the same time. By applying the necessary power the spiralifer can be made to act vertically or horizontally, or at any intermediate angle, so that we have in it an easily regulated and perfect driving power. The position taken up by the advocates of the screw is the reverse of that occupied by the advocates for the balloon; so that the aeronaut promises at no distant day to be fairly impaled on the horns of a dilemma, by having on the one hand a motor power which (because of the space occupied by it) no human ingenuity can direct; and on the other a thoroughly manageable and docile elevating and driving apparatus, minus an adequate motor power. The problem of flight will probably be solved by one employing a certain proportion of gas to assist him in overcoming the inertia of his machine while he uses the screw as a propeller and partial elevator. Of the two systems propounded, if they be judged separately, I incline to that which proposes to employ the screw both in elevating and propelling, and this for two reasons: 1st, Because the screw or a modification of it is the instrument by which, as I have shown, the insect, bat, and bird rises and progresses; and, 2d, Because a certain degree of weight is necessary to overcome the air and make it useful for the purposes of aerostation.

That the principle of the helice as applied to the air is correct is proved by the very remarkable experiments of MM. Pontin d'Amécourt and De la Landelle, both of whom have constructed within the last three years helicopteric models, which not only rise by themselves into the air, but also carry graduated weights.* The difficulties therefore attending aerial locomotion by means of the screw are already partially surmounted.

The advantages which will accrue from the employment of the screw in aerostation may be briefly stated.

It occupies little space, is strong without being heavy, and is prodigiously powerful.

It rigidly economizes the motor power by keeping the inclined planes of which it is composed closely applied to the air throughout its entire revolution.

The speed of the screw can be increased at pleasure—increased velocity, as I have shown in the insect and bird, conferring enormously increased propelling and lifting power.

By a judicious combination of horizontal, vertical, and oblique screws, almost any degree of speed may be attained, and any course, whether upwards, downwards, or forwards, pursued.

A machine elevated and propelled by screws will be necessarily a compact machine—a machine which will navigate the air as a master; its weight and the small surface occupied by it rendering it superior even to moderately high winds.

The nearer such machine is kept to the earth, and the greater the density of the atmosphere, the greater will be its facility and power—the inconveniences arising from temperature and excessively rarefied air being thus avoided.

The aerial screw machine should be constructed, whenever practicable, of hollow cylinders fixed into a floor, composed of one or more flattened cylindroid chambers filled with hydrogen or other gas to diminish weight. The flattened cylinders, if laid horizontally or inclined in a slightly upward direction, would act mechanically as sustainers and gliders, as do the wings in sailing and gliding birds. It is just possible that the motor power required for the helicopteric flying-machine may be derived from compressed atmosphere, the air being com-

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* Extracts from a paper, by Mons. Nadir, 1863, quoted in Astra Castra: By Hatton Turnor, London, 1865, pp. 340.

pressed by the aid of an engine on *terra firma*, and stowed away in the cylinders comprising the floor or other portions of the machine before starting.

When and where such a machine will be successfully launched no one can of course predict. The subject of artificial flight, however, has been so frequently discussed of late years, and has excited so much interest in America, France, and other portions of the Old and New World, that it must obviously receive a settlement in one direction or other at no distant date. Even Britain, involved as she is in business and politics, and caring little about science which is not directly remunerative, has made a move in this direction, and we have now the Aeronautical Society of Great Britain, presided over by his grace the Duke of Argyll, himself a Goliath in aeronautical matters. It were much to be desired that those who can afford the time or the means requisite for conducting experiments on a scale commensurate with the importance of the subject would lend their aid to this great public movement.

Homo Volans.—Whether the *genus homo* will ever be able, by his unaided exertions, to leave the scene of his joys and sorrows for the fields etherean, time only can determine. Borelli, a great anatomical authority,* made elaborate calculations to prove the absurdity of such an attempt. His calculations, however, will not deter the more sanguine and speculative portions of mankind from renewing their exertions in this direction as opportunity permits; and I may state, for their guidance in the matter, that if man ever flies it will not be by employing his arms simply, but by concentrating the energies of his entire muscular system—by transferring in fact the movements of his arms and legs to a central axis or shaft, surmounted by one or more horizontal and vertical screws of appropriate size and shape; these being made to revolve with a velocity to be determined by experiment. The value of this hypothesis could be readily tested, and at a trifling expense, by a machine constructed after the manner of a velocipede, which need not be of a very complicated character.

In order to construct a successful flying machine, it is not necessary to imitate the filmy wing of the insect, the silken pinion of the bat, or the complicated and highly differentialed wing of the bird, where every feather may be said to have a peculiar function assigned to it; neither is it necessary to reproduce the intricacy of that machinery by which the pinion in the bat, insect, and bird is moved; all that is required is to distinguish the form and extent of the surfaces and the manner of their application, and this has, in a great measure, been already done. When Vivian and Trevithick constructed the locomotive, and Symington and Bell the steamboat, they did not seek to reproduce a quadruped or a fish; they simply aimed at producing motion adapted to the land and water in accordance with natural laws, and in the presence of living models. Their success is to be measured by an involved labyrinth of railroad which extends to every part of the civilized world, and by navies whose vessels are despatched without the slightest trepidation to navigate the most boisterous seas at the most inclement seasons. The aeronaut has the same task before him in a different direction, and in attempting to produce a flying machine he is not necessarily attempting an impossible thing. The countless swarms of flying things testify as to the practicability of the scheme, and nature at once supplies him with models and materials. If artificial flight were not attainable, the insects and birds would afford the only examples of animals whose movements could not be reproduced. The outgoings and incomings of the quadruped and fish are, however, already successfully imitated, and the fowls of the air, though clamorous and shy, are not necessarily beyond our reach. Much has been said and done in clearing the forest and fertilizing the prairie: can nothing be done in reclaiming the boundless regions of the air?

* De Motu Animal.

MAN AS THE COTEMPORARY OF THE MAMMOTH AND THE REINDEER IN MIDDLE EUROPE.

Translated by C. A. ALEXANDER *for the Smithsonian Institution, from "Aus der Natur: die neuesten Entdeckungen auf dem Gebiete der Naturwissenschaften." Leipzig,* 1867.

While the eyes of inquirers were turned towards the east and followed with interest the excavations in Assyria and Egypt, in the hope of finding there something conclusive regarding the earliest condition of our race, similar researches in the drift deposits of France, Belgium, and England, in the silicious formations of those countries and in the oldest pile-constructions of Switzerland, Germany, Hungary, and Italy, brought to light incontestable proof that man had already obtained a firm foothold in different parts of Europe, at a time which ascends far beyond our chronology, and even lived cotemporaneously with the gigantic and partly extinct animals of the post-tertiary period; with the mammoth, the gigantic deer, the woolly-haired rhinoceros, the bear, the tiger, and hyena of the caves.

It will be understood of itself, that these discoveries were at first received with distrust, because they totally subverted all previous conceptions and could by no means be reconciled to the received theories respecting the age of the human race. Even Christol and Tournal, who, in 1828, made, in the south of France, the first discovery of fossilized human remains, mixed with fragments of pottery and the bones of extinct species of animals, ventured not to vindicate for this significant fact its just value, so firmly fixed in public belief was the doctrine of Cuvier that man had first made his appearance on the earth after the era of those primitive species. In the same manner fared it with the discovery of the Belgian explorer, Schmerling, who, in 1833, found, in some caverns near Liége, human bones intermixed with rude implements of stone and the remains of extinct animals, such as the rhinoceros, the mammoth, &c.; even the discoverer himself suggesting that it was possible that these relics might have been floated thither after the denudation of their original places of deposit. It was, of course, a striking circumstance that already a number of rude implements of stone had been found without the coincident occurrence of human remains; whence no particular significancy was attached to these when discovered, and many, without troubling themselves with further investigation, were content to assign them to a later date or to confound them with what they were pleased to call *sports of nature.*

Nevertheless attention had become more strongly excited, and similar discoveries, especially since 1840, stimulated further inquiries. Communications to this effect did not, indeed, at once receive a proper appreciation, but finally the grounds of proof became so preponderant that all objections of the skeptical were put to silence. Meanwhile the proofs have continued to accumulate, so that at length there remain no grounds of denying that man was an inhabitant of the earth at the same time with the gigantic animals of the quaternary period. The discoveries of late years enable us even to follow the human race through different phases of improvement during the prehistoric era.

At the commencement of the quaternary period the aspect of Europe, as far even as the latitude of Sicily, closely resembled that of the polar regions of to-day. The entire continent was wrapped in a shroud of snow; enormous glaciers covered the whole of Iceland, Scotland, and Scandinavia. All the valleys in

the Carpathian mountains, the Balkan, the Pyrenees, and the Apennines, were filled to the summit with ice. From the peaks of the Alps, which lose themselves in dense clouds, descended enormous glaciers which, towards the south, stretched into the plains of Piedmont and Lombardy, as yet covered by the sea, while, towards the north, another glacier, 720 square miles in extent and 36 miles in length, reached to the Jura. The European continent, however, was, at that remote period, of much less extent than at present. The more depressed parts formed then the bed of the sea, and what was not covered with water lay hidden, during the long winter, under the enveloping snow.

In the wastes of ice towards the north pole men contrive to live, but we find no trace of them in Europe at the time we are speaking of. But centuries elapsed, the snow gradually decreased, the glaciers retreated by degrees, as did also the sea, and a strange fauna occupied Europe: an elephant covered with crisped hair and having a long mane, a rhinoceros similarly protected, a hippopotamus which must have immigrated from the south through the mouths of the rivers, gigantic bears, a large kind of tiger, multitudes of hyenas of still existing species, a huge ox, &c. These animals subsisted together under a still rude, but less austere climate. At this time, also, man existed in Europe, in the midst of this not precisely idyllic fellowship!

Now, the question is this: In western Europe was man indigenous or had he migrated from Asia, together with the mammoth and rhinoceros? It would seem probable that, before entering Europe, he had inhabited Asia. During the great glacier period, the climate in southern Asia was less severe than in Europe, and therefore better fitted for the sustenance of man, whose dental system more nearly approaches that of the granivorous than that of the carnivorous tribes. It is, indeed, believed that, during the glacier period, Europe was divided from Asia, and that the two continents first became united after the retreat of the sea. At that time also, the first migration of mankind to the west must have taken place, induced by the desire of occupying the lands which had newly emerged from the waters.

In what light shall we picture to ourselves the condition of these men? The oldest implements of theirs which we possess, the traces of the hearths which served them to cook their food, certainly do not reach back to the earliest times of the existence of man upon the earth. However our pride may revolt at the fact, we are forced to acknowledge that man, as he stepped at first upon this part of the earth, bore, in his instincts, his passions and his wants, no small resemblance to the brutes. Fire was still unknown to him; his teeth show that he drew his nourishment from roots and other growths of the soil, and when he began to use flesh for food he must have devoured it raw. His unsettled life was exclusively devoted to satisfying his material wants; no idea had he of any exalted endowments; his speech would consist naturally of only a small number of words, in which, as is the case with the bushmen and other barbarous tribes, the vowels played a prominent part. A skin, stripped from the beasts he had slain, formed the clothing of the primeval European; his limbs were exposed to the inclemencies of the weather, and when he would seek rest or protection from the cold or from wild animals, his necessary resort was to the forest or to dark cavities in the earth. Yet, in spite of the humble stage at which man stood in this early period of his mundane existence, he was still the paragon of creation. He was gifted with reason, and this invested him with supremacy over the beasts of the wilderness.

In time, by means of the lightning and volcano, man would become acquainted with fire, and soon recognizing its beneficial activities would learn to preserve it as his greatest treasure. Since he knew not as yet how to produce it, he would carefully maintain it by day and night. Hence, in the earliest times, fire would naturally become the object of peculiar veneration. It must also have exerted a powerful influence on the conditions of human existence. To the roots and

rather unsavory products of the earth, flesh would more generally succeed as a diet, the means having been supplied of rendering it tender and digestible. Against the rigors of winter, fire offered its ready and invaluable succor. The continual reassemblage around the same hearth contributed in no small degree to the formation of the family.

At this geological epoch the level of the water sank more and more, so that the submerged lands of Europe rose gradually above the sea. The glaciers melted in part, and at that time the valleys began to exist. The part borne by the sea and by the water resulting from the melting glaciers in this first debâcle, admits of no accurate determination. From this period proceed also the deposits of rounded pebbles which cover in great part different regions of Europe. Another phenomenon stands in close connection with these great currents of water: the caves were emptied of the clay which had filled them.

Amidst this grand melting of glaciers, and the floods thereby occasioned, the volcanoes in Auvergne were emitting flames and lava. Their activity was witnessed by human beings, who became, in some cases, victims to their violence, as is testified by the human remains found in the volcanic tufa of Mount Denise de Velais. At the same epoch, herds of the gigantic mammoth and rhinoceros roamed over middle Europe and central Asia. With them were to be seen also the great bear of the caves, the colossal tiger, hyenas, the horse, and the larger ruminants. Man had at once to defend himself against the savage animals and to hunt them as the means of his own subsistence.

The animals which existed cotemporaneously with the fossil man were, according to geological researches, the following: the mammoth (*Elephas primigenius*, Blumenb.,) the Siberian rhinoceros (*Rhinoceros tichorinus*, Cuv.,) the hyena of the caves (*Hyæna spelæa*, Gold.,) the tiger of the caves (*Felis spelæa*, Gold.,) the gigantic deer (*Megaceros hybernicus*,) the bear of the caves (*Ursus spelæus*,) the reindeer (*Cervus tarandus*, Lin.,) the ure-ox and the aurochs (*Bos primigenius* and *Bison europæus*,) together with many of the smaller carnivora, insectivora, rodentia, &c. These animals, now in great part extinct or confined, like the reindeer and bison, to certain narrow districts, lived, probably, thousands of years before the era of the more recent pile-structures, whose occupants have left behind them, in their utensils and implements, the traces of an unfolding civilization, and had succeeded in domesticating some of the above species.

When we consider that the early men, with their miserably inadequate weapons, were called upon now to hunt such fierce and gigantic creatures as game, and now to contend with the more rapacious of them for their own lives and acquisitions, the remark of Lyell will not seem overstrained, that it is truly wonderful how the primitive man could maintain his existence in the presence of these formidable adversaries. But it must be remembered, in explanation of the fact, that in the case of these remote ancestors of ours, as in that of the rude tribes of the present day, the instincts which guide even the beasts were developed to a high degree of energy and cunning, so that it would be practicable for them to provide for their necessities and ward off apprehended dangers. In this, the reflective understanding gave even to the earliest of our race a superiority not to be undervalued, over the brutal force of the lower animals.

The power of endurance acquired by a life in the open air, partly in the recesses of the thick forests, partly in caves, the bodily agility and dexterity in the use of their certainly very primitive weapons, supplied, especially in a combined onset, something of the efficiency of our fire-arms; and the exhausted and incessantly harassed beasts would finally become the prey of the indefatigable huntsman. For, that our earliest predecessors were huntsmen and fishermen, the scanty subsistence afforded by the flora of that age permits us not to doubt. Many animals would be captured by means of pitfalls, as is now the case in Africa and other regions. On the other hand, we see that the Esquimaux of to-day, seconded only by their faithful dogs, and armed merely with

harpoons pointed with fish-bone, more rarely with iron, successfully attack the formidable polar bear; and the Indian of the Rocky mountains shrinks not from an encounter with the fearful grizzly bear, and proudly wears its captured claws as a trophy around his neck. With no less impunity does the Hottentot engage in combat with the lion, the rhinoceros, &c.; for artifice and perseverance everywhere secure to man a superiority over the beasts of the desert and forest.

Before those whom we call savages had come into contact with the European, they bore as weapons, with the exception of the North Americans, who were already in possession of copper hatchets and knives, only the simple bow and arrow, the lance and javelin. The oldest inhabitants of Europe had similar weapons pointed with flint, stone hatchets, such as are now in use in Australia, poinards of bone and buck-horn, lances, clubs, &c.; and hence weapons of such a kind as are now effectually managed by the wilder tribes of men. No doubt the aborigines of old had not less skill in the handling of their weapons than is now witnessed among the savages of Africa, America, and Australia; and thus is to be explained the possibility of resistance against the strongest animals, though, of course, the conflict of man with the latter must often have resulted disastrously to himself.

The expertness of the uncivilized races in the use of their weapons is, if the reports of travellers may be believed, something truly wonderful. Thus, for example, the Indian of North America transfixes with his arrows, at surprising distances, a horse or even buffalo; and a like skill was displayed by those natives of Cape York, in Australia, who were brought to England in 1853. They were able, without taking deliberate aim, to strike with their javelins, at a distance of 20 paces and with invariable success, a small object fastened to a stick. Captain Gay relates that the Australians generally are secure of killing a bird at the same distance, and Starbridge informs us that the natives of Victoria dive, with spear in hand, into the river Murray, and never return without having transfixed a fish. Certain tribes of Patagonians live almost solely on fish which, in diving, they sometimes take with the hands, or capture from the shore by means of wooden spears, like the Indians of California. The dexterity of the South Sea islanders in the water is such that, descending among the coral reefs, they thrust the fore finger into the eyes of any fish they have marked for prey, and thus bring it to land. The natives of Tierra del Fuego display singular skill in hurling stones, and not less the Hottentot in the use of his rakum-stick, a missile with which he dispatches the feebler species of animals at a distance of from 30 to 50 yards. The address of the semi-barbarous Guachos of South America in the use of the lasso is well known; nor is the Patagonian less adroit with his bolas, by means of which he throttles the puma or American lion before dispatching him. The Esquimaux also avail themselves, for the capture of birds, of a thong contrived on the principle of the bolas; it is a thin strap of leather, loaded at the end with a bone-knob, as the bolas is with a stone-weight, to facilitate its being wound around the neck of the bird at which it is cast.

The boomerang of the Australians is an instrument for hurling, which was long ago in use by the ancient fowlers of Egypt. Many of the peculiarly formed stone implements of the oldest stone period may well be supposed to have served chiefly as missiles, just as similar ones, made of iron, are employed in Africa; for instance, the lissam or crooked club of the negroes of central Africa, and the analogous hungamunga of the Tibboos, in the southeastern part of the Sahara. It cannot be doubted that the effectiveness of a skilfully thrown club or stone is little less than that of one of iron. It is therefore by no means necessary to assume that the aborigines of the earliest times must have wielded very heavy weapons, for it would appear, from what has been said, that those already found would have qualified their possessors to cope even with the colossal beasts of that remote era. Besides that the more ponderous animals would

be mostly captured by pitfalls, it has been seen that the American Indian pursues the buffalo of his hunting-grounds with proportionably feeble weapons, and that a single Esquimaux will enter into conflict with the polar bear when armed only with his lance. Among the Tschutksches, who inhabit the northeastern angle of Siberia as far as the Arctic ocean and Behring's straits, even boys of from 12 to 14 years attack the bears with spears five feet long, and succeed in killing them.

Opportunity is constantly afforded us of witnessing what can be performed by the ruder races of mankind with their simple implements. Stone knives of obsidian, for instance, are not uncommon in Mexico, and in certain cases they are even preferred to those of iron. We are told by Greton that the Damaras dismember without difficulty the largest animals, elephants and giraffes, by means of the poorest instruments—thin pieces of iron fixed in a short handle—while he himself could scarcely even pierce their hides with European knives of the best quality. The Caffres show remarkable skill in striking an object with their peculiar missile at a distance of 20 or 30 paces. In doing this, they seize the assagay between the thumb and upper finger joint, the point in front, raise the hand to the level of the shoulder, not higher; draw the arm back and contrive, by striking the shaft against the wrist, to give it a vibratory motion from point to butt, hurl it with great force, and the weapon, still vibrating during its passage through the air, seldom fails of attaining its aim. To the same effect may be cited their knob-kerris, sticks of an inch in diameter and four feet long, terminating in a large round knob. These are usually cut from the off-shoots of the wild olive tree, and are employed by the Caffres in hunting wild beasts or destroying serpents. For this purpose they lay hold of the shaft of the weapon, measure with the eye the distance of the object, and throw the stick in such a manner that, circling in the air, the thinner end shall strike the ground a few feet from the point aimed at, and the knob fall, in the rebound, directly on the victim. Equipped with such slight arms as these the Caffre seems insensible to danger, and war has shown that, in bush-fighting, the best English troops are scarcely a match for him.

We are, of course, not in a position to pronounce with certainty in what manner the primitive man hunted those animals of which we have been speaking. Had he been in possession of more formidable weapons than have been as yet recognized, it is hardly possible but that some of them would have been found. But that the animals in question existed as cotemporaries of man, and served him for sustenance, has been placed beyond a doubt, and, in his encounters with them, the primitive weapons of stone which have been already discovered will appear to have been no such mean auxiliaries, when we consider the effects produced by the analogous and simple instruments wielded by the uncivilized tribes of the present day.

This contest with the untamed animals gave the first impulse to an industrial activity among men. Before all else the preparation of weapons was to be thought of. Metals were then unknown, and men seized upon stone, especially that known as flint, whose aptitude for piercing or cutting was easily recognized. From this hatchets and the points of lances were formed and fitted to wooden handles. The insufficiency of these weapons led to progressive adaptations. The beasts might fly, and must be overtaken by missiles; hence the javelin. The fugitive beasts are not in this way easily reached; a step in advance, therefore, was the bow, which sends the arrow to a greater distance. The idea of this was found in nature: man had before his eyes the curvature of branches of trees by parasitic vines, and witnessed the elastic force thereby developed. The cord of the first bows was supplied by strips cut with sharp stones from the hides of animals, and the arrow was equipped at one end with a point carefully wrought from flint. Stimulated by his necessities man would soon learn to resort to ambush and other stratagems, and, gradually emboldened by success,

he would no longer fear to attack, even with his rude and imperfect weapons, the mightiest denizens of the wild—the mammoth, the rhinoceros, and the bear; nor was it seldom that these fearful enemies fell before his prowess or his craft.

The sedimentary deposits of this era contain numerous evidences of the industry of these first men, together with their own bones. The celebrated discoveries in the neighborhood of Abbeville, which we chiefly owe to the assiduous researches of Boucher de Perthes, have furnished so many contributions to our knowledge that we can now figure to ourselves an image of those far remote and obscure centuries during which mankind lived in caves of the earth, and merely added to the stock of their implements by the employment of the bones of wild animals in addition to the use of flint.

The few very ancient skulls hitherto found authorize us to speak only with great reserve of the type of the races of men existing at that remote period. The skull discovered in a cavern of the Neanderthal, near Düsseldorf, exhibits an unusual thickness. The projection of the supra-orbital ridges is enormously great, the forehead narrow and very low. The development of the brain was slight, and similar to that of certain Australians. Carl Vogt is of opinion that this skull and that found by Schmerling in the cavern of Engis, near Liége, are remains of a race no longer existing in Europe. But scattered discoveries like these scarcely entitle us to such positive conclusions; it were well to await further revelations before resigning ourselves to any settled determination on this point. The size of the men of that distant date was not greater but rather less than at present, notwithstanding the belief so generally prevalent that in prehistoric times our earth was inhabited by a race of giants. For the origin of this belief we must look to the large elliptical mounds which occur in certain districts, the so-called graves of the giants, in which are found in great numbers implements and weapons of stone, indicating that these graves belong to a far-distant age and were receptacles for the dead bodies of a primitive people. These graves are sometimes more than a hundred feet long, so that, in comparison, our modern sepulchres are mere molehills. But it is an error, from the magnitude of the graves to infer that of the bodies deposited therein. As the dead, at the epoch in question, were buried, at least in part, without previous incineration, tolerably well preserved skeletons have been obtained from the tombs, and these skeletons evince that, so far from being the remains of giants, they are those of a race inferior in stature to the ordinary proportions of the Caucasian. The age to which these gigantic tombs are to be assigned cannot be exactly determined. Nor should we be justified in assuming that those who were deposited in them belonged to the earliest race of men who inhabited Europe after the disappearance of the icy investiture which, in the judgment of the most recent and judicious inquirers, wrapped that continent almost from side to side at the beginning of the present geological era; for the implements of stone so commonly found in the tombs bear witness to a considerable degree of skill, while the tombs themselves show that the builders had made no contemptible progress in that branch of mechanics which is occupied with the management of heavy masses.

The strong projection of the superciliary ridge may possibly be a consequence of the manner of life led by these cave-dwellers. They must need be always on the look-out against the beasts of which they were in fear, or searching anxiously for such as it was their business to capture for food. By this incessant effort of visual attention, the muscles of the part in question would become disproportionately developed, and the physiognomy be impressed with a peculiarly wild and fierce aspect.

Were the men of that distant time cannibals? The question scarcely admits of being positively answered. In Scotland, different skulls have been found, of which some bear a resemblance to those of the ancient Britons, others to those of the Australians. Together with these have been discovered bones of children which, according to Owen, bear upon them the traces of human teeth. Inter-

mingled with these remains, arrow-heads of flint occur and pottery of a very rude description. Spring, who carefully examined the bones of children which were found in Belgium, in the grotto of Chauveau, also arrived at the conclusion that they were the remains of a repast made by cannibals. The proof offered by these facts, however, is not of a convincing kind; on the contrary, it has been met by strong objections. If men in the quaternary period devoured their fellow-creatures, it is difficult to suppose that the marrow of the bones would not be a delicacy as eagerly sought as was that of the beasts slain in the chase. But no human bones are found which have been opened in such a way as to extract this much-coveted substance, while everywhere occur in abundance the bones of mammalian animals which have been evidently fractured for that purpose.

A question has been suggested by Horn whether the marrow of the longer bones of animals served the primeval men simply and solely as nourishment? It may have been used also for anointing the body, as well for protection against noxious insects as against cold. Nor is it unlikely that one of its economical uses may have been for rendering more pliant the skins which served for clothing. As an article of food the marrow must have been devoured raw, for most of the bones show that they have undergone no action from fire. Indeed, during the earliest stage of man's existence in Europe, fire would seem to have been unknown for any such purpose, as were also vessels artificially made of earth; and if the marrow was to be melted for the processes just mentioned, it could only be effected by the heat of the sun and in cavities of the rocks.

It has been remarked that in the bones of the human jaw which have come down to us from the still more recent age of stone, the incisor teeth are greatly worn. Hence it has been hastily inferred that flesh was then eaten uncooked; but this view is in conflict with the discovery of charcoal under circumstances which imply the former existence of a hearth; nor is it to be supposed that, after having learned the economical uses of fire, men would continue to devour their food raw. The abrasion of the incisors might perhaps proceed from a peculiar mode of mastication. At this day the Esquimaux are said to use the front rather than the molar teeth in manducating food.

The caverns in which at that remote era the bear, the tiger, and the hyena found a lair, are easily distinguishable from those selected by man as a habitation. In the former, the bones which occur are unbroken; they bear merely the traces of having been gnawed by carnivorous beasts. In the haunts of the human being, on the contrary, the bones are always broken in the direction of their length, for the purpose of extracting the marrow. Our primitive ancestors devoured indiscriminately the horse, the ox, the bear, the tiger, and even the rhinoceros, provided the chase was successful. If the mammoth fell into their hands, the thick integument of the animal must indeed have been a prize for their rude dormitories.

This first age of man must doubtless have comprised thousands of years. We know how slow has been the development of the human race, and from the consideration that each generation stands on the shoulders of the preceding and civilization is but the product of the past, we can readily apprehend that the process of improvement must have been tardy and difficult in proportion to the distance of time which separates us from the period under contemplation. Accelerated progress comes only with the experience and facilities of multiplied years. Long must have been the ages when man's life was but a struggle for existence and for the bare satisfaction of the meaner necessities of his nature. Discoveries have been too few and indecisive to afford us any distinct image of the habits and mode of life which characterized this primordial condition of our race; but it is gratifying to add that a discovery has at length been made which seems to lead in that direction, and which is the more important inasmuch as it has given a renewed impulse to explorations of the same kind.

In the year 1852, a laborer, named Bonnemaison, employed in repairing the

roads near Aurignac, in the department of the Upper Garonne, observed that rabbits when pursued took refuge in a hole on the slope of a hill in the vicinity. Into this hole he thrust his arm, and, to his surprise, drew forth, not a rabbit, but one of the long bones of a human skeleton. Proceeding to dig into the hill, he encountered a large flat stone standing erect and closing a cavity into which the rabbits had wrought an entrance. When Bonnemaison had removed the stone, he saw before him a natural cavern wherein lay not less than 17 human skeletons. The discovery naturally caused a sensation in the neighborhood, and unfortunately the mayor of Aurignac, Dr. Amiel, felt himself bound in duty to have these human remains transferred to the churchyard and again buried. Not the slightest misgiving seems for a moment to have been entertained by this conscientious functionary that he was wresting from science an invaluable treasure. When Lartet visited Aurignac, eight years later, and heard of this interesting discovery, no one, not even the grave-digger, could point out the spot where the skeletons had been interred. Thus this rich harvest of ethnological knowledge seems forever lost to the antiquary and geologist.

Lartet nevertheless failed not to visit the cavern, and to institute further researches. The rubbish which for hundreds or thousands of years had been descending from the summit of the hill had buried the stone by which the mouth of the grotto was closed, and had also covered a small terrace which existed in front of it. These accumulations being removed, the original surface was again exposed to view, and upon this were found a number of calcareous stones, the remains of an ancient hearth, as well as the bones of many different animals and objects of human industry. In the bed of earth which covered the floor of the grotto were found bones of the cave bear, the aurochs, the horse, the reindeer, &c., which had been neither broken nor gnawed, and, besides these, instruments of flint-stone, a weapon constructed of the antlers of the reindeer which had been sharpened at one end, together with 18 small disks formed of a white shelly substance and perforated through the middle. These last were recognized as being derived from shells of a cockle *(Cardium)* which is an inhabitant of the ocean.

The bones found on the terrace before the grotto had all been fractured, as if to lay bare the enclosed marrow. Still distinctly to be traced were the notches made by the stone hatchets or knives which had been used to detach the flesh, as well as marks of the teeth of the hyenas which had resorted hither during the night to feast on what remained of the spoils. Even the excrements of these wild animals were still distinguishable. Some of the bones bore traces also of having been submitted to the action of fire. The list of the animals to which the bones pertained was by no means a brief one. Among extinct species were recognized the mammoth, the rhinoceros, the gigantic deer, the great bear and tiger and hyena of the caves; among those still existing, the aurochs, the horse, the ass, the stag, the reindeer, the roe, the wild boar, the wolf, the fox, the badger, and the polecat.

The objects of human art and industry found in front of the grotto were very numerous. Sharpened instruments of flint, mostly knives, were discovered to the amount of not fewer than a hundred, and, mingled with them what appeared to be missiles intended for the sling. The circumstance that these objects were accompanied by cores or nuclei of flint, the material from which they were made, would seem to indicate that some of them had been manufactured at this spot. Other objects also were found in considerable number, wrought of bone, and especially of the antlers of the reindeer, such as points for arrows without barbs, a shape with which we become familiar at a later age; a bodkin formed of the more compact bone of the roedeer and sharply pointed, so as to be well suited for piercing the hides of animals in sewing them together; and still another of smaller size, provided with a very sharp point, which had probably been employed for tattooing. Many flat pieces of reindeer's horn, polished on both sides, closely resemble, according to Steinhauer, of the museum of antiquities at

Copenhagen, certain implements still in use among the Laplanders for pressing the rough seams. Another plate of the same substance exhibits on one side many transverse lines traced at equal distance from each other, and interrupted in the middle so as to form two rows. On both faces of the plates are notches cut still deeper than the lines, but also at equal intervals. May not these have been counters for marking the values of different objects, or, as Steinhauer conjectures, memorials of the chase? Finally, a fang of the cave bear, *(Ursus spelæus,)* perforated lengthwise, as if for suspension as an ornament or amulet, affords us rather an elaborate work of men's hands, a primitive attempt of art to imitate the animal form, being carved into the rude likeness of the head of a bird.

It is not without interest to remark that the bones of the carnivorous animals found around the hearth were entire, and showed no mark proceeding from the use of the flint knives. Even the hyenas appear to have rejected them. The bones which had been opened and were gnawed, belonged especially to the aurochs, *(Bison europæus,)* the reindeer, and the horse. The skulls of these animals were wanting; probably they had been broken to pieces in order to come at the brain, and the fragments thrown into the valley. Pallas tells us that, at this day, the Samoeides eat the brain and marrow of the reindeer raw.

From the above facts Lartet has drawn the following conclusions: The burial-place of Aurignac reaches back to the highest antiquity of our race; a proof of this is furnished by the fauna found on the site, and which in part has long disappeared from the earth. The depth of the layer of ashes, as well as the great number of animal bones, show that, in front of this grotto funeral feasts were held, and that it has been opened at different times to receive new bodies, until the cavity was filled. On the other hand, the uninjured bones found in the interior of the cave evince that offerings have been here consecrated to the dead. The various implements were deposited that the deceased might avail themselves thereof on entering upon another life; a custom which we know to be still in use among various uncivilized tribes. The carnivorous animals which man seems not to have eaten may, by means of their skins or in some other manner, have borne a part in these primitive rights of sepulture.

The absence of all traces of pottery is a further proof of the very remote antiquity of the human remains here discovered. We see, however, that, even at that distant time, man was not destitute of a certain degree of practical skill. Already there are instruments of horn, and the bodkin in particular was not ill adapted for sewing together the skins which protected the person from thorns as well as cold. Nay, the rude inhabitant aspired to some amount of luxury, though, it must be confessed, of a very primitive sort. The disks pierced in the middle must have served to form either an armlet or necklace, and in the bear's fang above spoken of we have perhaps the oldest monument of art which has descended to us from its earliest infancy.

When Bonnemaison, the laborer who discovered the grotto, first entered it, there were within it several entire skulls. According to the recollection of Dr. Amiel, who counted the bodies, the remains were those of a race under the average size, and the skulls were brachycephalic or round, which accords with the discoveries made at Moulin Quignon, and in other caverns. A human maxillary bone found by Lartet, imbedded in the loose soil within the grotto, points also to the same inferiority of stature.

In reference to these discoveries Sir Charles Lyell expresses himself in the following manner:

If the fossil memorials of Aurignac have been correctly interpreted—if we have here before us at the northern base of the Pyrenees a sepulchral vault with skeletons of human beings, consigned by friends and relatives to their last resting place—if we have also at the portal of the tomb the relics of funeral feasts, and within it indications of viands destined for the use of the departed on their way to a land of spirits—while among the funeral gifts are weapons wherewith in other fields to chase the gigantic deer, the cave lion, the cave bear

and woolly rhinoceros—we have at last succeeded in tracing back the sacred rites of burial, and, more interesting still, a belief in a future state, to times long anterior to those of history and tradition.

It may perhaps seem strange that this depository of the dead at Aurignac should have been preserved for us so many thousands of years, and not have been swept away by the diluvial cataclysms. But when it is considered that, excepting at certain points where the upheaval of the soil has been distinctly ascertained, the height of these inundations over the regions in question has not exceeded 600 to 750 feet, it is clear that the grotto of Aurignac, which has an elevation of 1,290 feet, was beyond their reach. There are various other caverns, moreover, in which proof exists of the cotemporaneous existence of man and extinct animals of the quaternary period. In a general point of view, these caverns may be divided into three groups, those which have been inhabited by men, those which have served as burial places, and those which have formed the lair of the greater carnivorous animals. These last contain numerous bones, the remains of the prey dragged thither by such wild beasts as the tiger, the hyena, and the bear. The bones are gnawed, never split lengthwise, nor do any traces occur which would point to the presence of the human race. The caverns, on the other hand, which have formed the habitations of man are readily to be distinguished, even in the absence of human remains, by the existing bones being cleft lengthwise in the manner which was uniformly employed to get at the marrow. In certain caverns are found one or more overlying strata containing remains and corresponding to different epochs. The grottoes which have served as burial places are usually small, and entered by a narrow passage, so as to be readily closed by a flat stone in order to protect the dead bodies from the rapacity of hyenas and other carnivorous animals.

It is easily conceived that many caverns exist which do not fall within either of these three classes. Some of them, which have two entrances, may have been emptied of their contents by floods, or been completely filled up with mud and rubbish. Others have been inhabited by man, after having been previously occupied as dens by wild beasts. Others still have been hollowed out by men, in order to be used for different purposes. In the latter, as in those exposed to the action of water, much circumspection is requisite to determine the age of the remains which are found therein.

The principal caverns pertaining to the age of the great cave bears are the following: (1.) The grotto of Vallieres, in the department of the Loire and Cher. It contains bones of the rhinoceros, the hyena, the gigantic deer, the bear, the aurochs, a horse, *(Equus adamiticus,)* mingled with stone hatchets, of the kind found in the valley of the Somme. (2.) The grotto of Arcy-sur-Yonne. Under a more recent deposit it presents two strata of the quaternary period. Here were found bones of the elephant, the rhinoceros, the bear, and the hyena, intermingled with stone implements; also the two branches of a human under jaw, with teeth well preserved. (3.) The cave of Fontaine, in the environs of Toul, containing bones of the bear, the hyena, and the rhinoceros, as well as objects of human industry, including a needle of bone, provided with an eye. (4.) The cave of Pontil, in the department of Herault. It contains a lower bed bearing the remains of the large extinct animals, and an upper one with human remains, charcoal, and implements of stone, bone, and buckhorn, mingled with the bones of horses and bisons. On the surface have been collected the bones of the polecat, together with smooth stone hatchets, and objects which point to the age of bronze. (5.) The grotto of Moustier, in the district of Peyzac, (Perigord.) Here were presented the remains of the cave hyena, the great bear, and scales of the molar teeth of the elephant, such as were found at Aurignac and other places which had been inhabited by men. With the animal remains were mingled stone implements bearing a resemblance to those found at Abbeville. (6.) The upper grotto of Massat, in the department of Ariege. Here, besides many animal bones, have been recovered two human teeth and an arrow-head of bone.

The caverns in which such discoveries have been made are not confined alone to France; in other countries revelations of the same kind have taken place. Thus, for example, Colonel Wood has brought to light, in the cavern of Longhole, (England,) the remains of two different species of the rhinoceros, (*Rhinoceros tichorhinus* and *R. hemitoechus*,) together with knives of flint. In the cave of Wells, in Somersetshire, in the Wokey cave, and in several caverns of the peninsula of Gower, in Wales, bones of extinct animals have been found, but the cotemporary presence of man has not as yet been substantiated. The celebrated Gailenreuther cave in Franconia is well known to be rich in remains of wild animals. The grotto of Chiango, near Vicenza, and that of Laglio, on the shore of Lake Como, contain numerous bones of cave bears, mixed with some implements and the relics of rude earthen-ware, a rare contribution from so remote an epoch of the human race. In Sicily have been found, in the grotto of Macagnome, bones of the *Elephas antiquus*, a cotemporary of man, together with bones of other beasts, and the remnants of human industry. Were we to enumerate all the caverns of this sort, the list would be a long one. We find such in all parts of the earth, and it is not seldom, as for instance in Syria, Brazil, &c., that they afford evidence of the cotemporary existence of man and fossil species. Nor are the discoveries which prove this synchronism of man with the great extinct mammalia limited to the caves alone. The valleys of the Somme, the Thames, &c., furnish the traces of human industry in the form of implements wrought of flint-stone, in common with the bones of the mammoth and rhinoceros. Especially rich are these kinds of depositories in France, Belgium, and England.

But how was it that man and these great mammalia of the quaternary era penetrated to England, after migrating from the north of Asia, where they perhaps existed at the pliocene period? It is readily seen that the migrations may have taken place before the irruption of the waters into the English channel, or if later, over the ice of the frozen sea, for the winters, at the date of the upper silicious deposit in the valley of the Somme, must have been very rigid.

The era of the cave bears embraces several thousands of years. During this period the temperature in Europe was less inhospitable, but on the approach of the epoch known as that of the reindeer a recurrence of intense cold must have taken place.

It is now some 30 years since the statement was authoritatively made in Switzerland that the glaciers had, at a geological period of the earth's history which can scarcely yet be considered as having passed away, occupied a far wider extent than at present, and not only descended to the level country, but piled themselves to a considerable height against the wall of the Jura, opposite to the Alps. Regarded at first by the older geologists as a rash and visionary hypothesis, the glacier theory has continued to gain ground, basing itself on researches restricted to no latitudes, but laying under contribution alike the north and south, the mountains and the valleys; so that in these later times its most bigoted adversaries will scarcely venture to deny that it has always followed with scrupulous steps the observation of facts, and has never accepted anything as proved which could not be established by direct reference to the glaciers and arctic seas of the present day.

The rocks of Norway and Sweden, as well as those of Iceland, are in so many places rubbed away, scratched and furrowed, that it may with certainty be assumed that the agent by which these phenomena were produced has been in operation over the whole region, and that where they fail to appear they have been obliterated by subsequent influences, particularly elementary abrasion. The polished and furrowed surfaces, all tending in a certain direction, are found at a height of 5,000 feet in the Norwegian mountains, so that few peaks and ridges rise above the level of the phenomenon. This has undoubtedly greatly contributed to the uniformity of outline in the mountain chains of Norway; while in the Alps, where the height of the phenomenon reaches 8,000 feet, the

uniformly rounded summits, the bellying convexity, as it is called, of the surface show themselves only below that limit, and above it first commences the peculiar form, the individualizing structure which gives to the whole chain so striking and sublime an effect.

As in all other mountain ranges, these scoured and furrowed surfaces stand here in the most exact parallelism with the heaps of gravel and sand, as well as the boulders, which occur now on the sides and now on the beds of the valleys, and which have evidently been transported from far distant localities. In Scandinavia, equally as in the neighborhood of the Alps, hundreds of places can be pointed out where blocks of enormous weight and magnitude with sharp edges, and which can therefore by no possibility have been rolled, are found leagues away from their place of origin and deposited on a substratum of rock widely differing from their own structure. The direction of the furrows and striæ on the abraded surfaces accords with the route which these blocks must have followed in their migratory movement; as it shows also the points from which the moving force derived its impulse.

In various charts the observations made in Scandinavia and Finland respecting the form and arrangement of these abrasions have been collected and compared. Conformable for the most part with the direction of the great valleys and the general slope, the highest point of which is found in the long coast-chain of Norway, there are yet points where isolated mountain summits rise, as in the Alps, to a loftier altitude, and from these the traces of the abrasion radiate into the subjacent valleys.

From a collation of the phenomena under consideration, the abraded surfaces with their rounded outlines and linear furrowings, the angular and unworn erratic rocks, the accumulations of gravel and sand which either run along the sides of the valleys or form in their beds transverse walls or ramparts, convex in the direction of the descending slope, there can be no longer any reasonable doubt that we have before us in these phenomena the work of glaciers—glaciers which once covered all the surfaces on which this assemblage of phenomena presents itself, and which therefore overspread as with a continuous roof of ice the whole of the Scandinavian peninsula and Finland.

M. Kjerulf, of Christiania, calls notice very justly to the observations of Dr. Rink, who passed several years in Greenland and there attentively studied the ice envelope of the interior country. A continent of wide dimensions, not smaller than the whole Scandinavian peninsula, is here seen covered with an enormous ice-crust, which attains a height of 1,000* feet, and which exhibits a general movement from the interior towards the western coast. Slowly but steadily does this mass, bearing its adventitious freight of rocks, glide downward to the sea, where it breaks off in immense fragments; and it is these fragments which as icebergs, often of colossal size, are borne by the ocean currents even as far as the latitude of the Azores, melting away gradually in their progress, and depositing their rocky burden on the bottom of the sea.

Precisely the same phenomenon was once exhibited in Norway, Sweden, and Finland. The land was hidden under a vast covering of ice, which carried down towards the sea the pebbles and gravel, or, if the expression may be allowed, the emery which served this stupendous polishing apparatus as a substratum. The whole mass of Norwegian rock was worn down and striated as we now see it; but the Arctic ocean itself which surrounded this pre-historical Greenland stood at first deeper than the present one; for at many points the abraded surfaces, with the furrows well preserved, stretch down under the water. If this circumstance be not of itself sufficient to explain the refrigeration of this northern region in a degree equal to that of Greenland, it is to be considered that the greater elevation of the land above the sea must to some extent have co-operated to that

* 2,000 feet perpendicular at the heads of the fiords which intersect the coast. (*Lyell's Ant. of Man.*)

effect. But where surfaces abraded by the glaciers show themselves under the present sea the water must certainly have once stood at a lower level, for the ice descends not beneath the plane of the sea, but is melted and undermined by the latter, as is witnessed in the case of the polar glaciers, under which explorers have found it practicable to penetrate at ebb tide to considerable distances.*

The sea meantime climbed upwards, the land became warmer, the general ice-envelope melted, the loftier ridges came to light, while the glacial mass separated into isolated glaciers which filled the valleys to their mouths. Now, first occur distinct moraines, as in the glaciers of to-day, lateral moraines, terminal moraines, ramparts of rock heaped in lines, of which the outermost stretch to the present coast, while the innermost rise to a certain height on the walls of the valleys, or form barriers across them, where they denote the halting point of the retreat before the sea. The sea followed to the height of some 500 feet, for at this elevation are found banks of shells containing mollusks which belong to the Arctic ocean. At the same time the mighty masses of ice, as they melted, gave forth streams which, dammed up here and there by the terminal barriers of the glaciers, formed inland seas, while the fine material, which all glacier currents bear along with them in great quantities, settled down in the form of clay, marl, and sand. The ocean on the one side, the inland waters on the other, plied their work of erosion on the older masses underlying the ice envelope; the glaciers continued to bring down erratic blocks which, after being long charioted on their icy vehicle, finally sank on the sites where we now find them. And thus was gradually brought about the geological period, in which the glaciers extend only at a few places to the sea, or else impend at a considerable height above its level, while in the bosom of the valleys reigns, for the most part, a mild and genial climate.

This prehistorical glacier period of the north is no romance; its consistency with observed facts is undeniable. The series of these facts is thus given by M. Kjerulf:

> What do we find to be the prevailing arrangement among these glacial masses piled up and distributed by the sea? Undermost, where they could not again be subjected to the action of water, sand, and rolled stones, that is to say, scoured sand and stones. In these we have the material which was moved forward under the pressure of the ice over the face of the rock. Would we learn the direction of the scouring process, it is to the blocks thus moved that we must have recourse. As these are mostly broken to pieces, small and rounded, they have been called "rolled stones," though this, strictly speaking, is an improper name, and they might more properly be called "scoured stones." They have not been rolled, but have been reciprocally crushed by one another, and fixed in the ice, like the diamond in the graver's burin, they have traced furrows and striæ in the subjacent rock. Above the scoured sand banks of rolled stones lie the different sorts of loam; first, calcareous loam, marl loam; in precincts open to the waters of the glaciers, sedimentary lime and loam brought down from the silurian strata; next shell loam generally, where the elevation was not too great or the currents of cold, fresh water, produced by thawing, not too powerful; then brick earth, without shells, referable perhaps to an age when the inundation of the interior country was at its highest; then sand, and on the top of all sand loam.

The great erratic blocks first occur above the beds of scoured stones, loam, and sand; in Scandinavia they have been brought into the position in which we now find them in some instances by cakes of floating ice, but for the most part by the glaciers themselves.

We have thus a long tract of time before us, during which a state of things like that now existing in Greenland prevailed, and an icy ocean washed the

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* The statement given by Sir Charles Lyell, in his Geological Evidences of the Antiquity of Man, varies in some respects from the views of the text: "When these masses of ice reach the friths of Greenland they do not melt or break up into fragments, but continue their course in a solid form under the salt water, grating along the rocky bottom, which they must polish and score at depths of hundreds, and even of more than a thousand feet. At length, when there is water enough to float them, huge portions, having broken off, fill Baffin's bay with icebergs of a size exceeding any which could be produced by ordinary land glaciers." (*Chap.* xiii.)

glacier-crowned coasts of Scandinavia and Finland, which together constituted at that time a separate continent. But it is not in this frozen continent alone that the proofs of such a polar sea are to be found. The whole level country of central Europe from Holland to Russia is strewn with erratic blocks, with rolled or scoured stones, which have all been derived from Scandinavia and Finland, and whose southern limit is determined by the elevation of the land which passes under the name of the Weser chain, the Hartz and Erz mountains, and the Riesengebirge. To the east the limit of these erratic blocks winds through the Russian lowlands to the Ural, and thence around to Finland by so regular a curve as to be almost susceptible of being described with a pair of compasses on the map. Here, then, we have the circle of dispersion of the icy ocean in question, within which the blocks were stranded, and from the circuit of which it is at once to be discerned that the Scandinavian-Finnish region was an island, and that a broad arm of the sea connected the present Arctic ocean and the White sea with the Baltic.

II. More than 20 years ago, an English geologist, Smith, came to London with a collection of shells, which he laid before the director of the appropriate department of the British museum, with the request that he would pronounce on their value and import. "My dear sir," said the director, after a cursory examination, "you have been taken in by some whale fisher; these are muscles which have been picked up on the shores of the Arctic ocean, but they are in bad condition, weather-worn, and in part broken to pieces, and are at best only fit to be thrown into the street." "I did not buy the shells," replied Smith; "I collected them myself from a stratum of argillaceous earth on the banks of the Clyde, in Scotland, where they form an ancient sea-beach." Nor was there in this any misrepresentation; there exists in Scotland a formation which contains a complete arctic fauna of the class of shells in question.

Since that time such researches have been multiplied. In the whole extent of the North American continent as low as New York, in England and Scotland, in Scandinavia and Finland, and far to the east among the wastes of northern Russia, occur everywhere the same formations; banks of rounded stones, (*Scheuersteine*,) with superincumbent clay, marl, and sand, containing the specific mollusks of the high Arctic seas, or such kinds as only attain their full dimensions in those waters, but which degenerate more and more in size as they approach a southern latitude; whence it is to be inferred that their true home must be sought in the higher regions of the north.

Quite recently Sars, of Christiania, has directed his special attention to the shell banks, which occur in southern Norway, and has, with his characteristic sagacity and knowledge of the distribution of individual species, combined the results of his observations. From the collections of shells as well as from their geological stratification, he has been enabled to distinguish two different groups of shell deposits, of which one corresponds to the highest advance of the Arctic sea, the other to the later epoch of its retreat. To the former are related the more elevated accumulations of shells, which reach a height of more than 400 feet above the present level of the sea, and the deposits of loam which lie immediately above the gravel and rounded stones, attaining at most a height of 240 feet above the sea. These are the lines of strand and the more deep-lying deposits of the glacial sea at the period of its greatest extension. In these deposits of the sea, at its highest elevation, there are found, according to M. Sars, either species which occur only in the north of Norway, and on similar glacial lines of coast, or else such as, when met with in South Norway, England and Scotland, evidently languish and contrive to subsist only under a diminished form; while on the north coast and in the Arctic ocean, where the full conditions of their existence are present, they attain the size which they exhibit in the geological strata. Here, then, the high northern fauna flourished in its fullest development, and those species which at present only reach their full size and complete organ-

ization in a glacial sea, maintained them at that distant time in one which washed the southern coasts of Norway. A further note-worthy fact results from these researches of M. Sars. There exists on the northern and western coasts of Norway a beautiful coral, which forms large rose-colored branches, and which is only found in the rocky chasms of the ocean, at the immense depth of 900 to 1,000 feet. C. Vogt collected some pieces of this coral (*Lophelia prolifera*) during an excursion to the Pippertind glacier, where the poor Laplanders of the coast, in fishing for cod, had probably brought it up from the sea with their angles.

This coral likewise occurs in the older shell-strata, but only in those beds which lie almost immediately on the beach of the sea, or under its level at a depth of from 60 to 90 feet. In these old submarine banks of shells the stems of the coral are still adherent to the rocks, but they are all dead, since the depth of water requisite for their life is wanting. These facts admit of an easy explanation. At the time when these zoophytes lived, the sea stood some 600 feet higher than at present, and, of course, there was the depth of water required for their existence.

Above these older strata, with their testacea of the high north, lie now the more recent shell-strata which ascend to a level of some 300 feet, and correspond with the period of the retreat of the glacial ocean. Here the remains of the same shell-fish occur, which live at present on the south coast of Norway, though isolated species are also present, derived from the arctic fauna. The arctic species had in general withdrawn towards the north as soon as the retreat of the sea commenced, while the temperature of the subsiding waters became like that which now prevails along the coasts of Norway.

All these results are further confirmed by discoveries recently made in the depths of the great Swedish lakes, the Wettersee and the Wenersee, and which have been described by Lovén from his own observation. In effect, there have been here captured specimens of crustacea, several species of which, though very different from those now living in the sea, are clearly related to marine forms; among these a species, *Misis relicta*, (Geisselkrebs,) whose congeners live altogether in the ocean, and those resembling this new variety only in the most northern latitudes. Another, of the species *Gammarus loricatus*, which is, thus far, found only in the Arctic ocean, in Baffin's bay, Greenland, and Spitzbergen; the *Idothea entomon*, (Schlachtwurm,) which only occurs in the Arctic and the Baltic; and still another, a small *Pontoporcia affinis*, which is still found in the Baltic, but whose related species only occur in the Greenland seas. These singular discoveries show clearly that the Wenersee and Wettersee, the former of which has an elevation of 300 feet above the present plane of the Baltic, were formerly in communication with the general ocean. At that time, therefore, these lakes were deep fiords, colonized by a marine fauna which altogether resembled that of the polar ocean, and the period of communication undoubtedly corresponded with the higher advance of the glacial seas as indicated in Norway and Sweden. The sea subsided or the land was upheaved; the inlets were more and more detached, and finally altogether separated from the sea, and have since slowly and gradually been filled with fresh water; this change having been effected apparently as well by sources in the bed of the lake as by the few tributary streamlets. Now, few marine animals endure the sudden transition to brackish water, and fewer still, when the change is very gradual, allow themselves to be borne over into it. The colony of the sea gradually died out, leaving in the depths only a few crustacea, which, as has been seen, correspond in part to the species of the Baltic sea, and in part to those of the Arctic ocean.

But there are other not less interesting conclusions to be drawn from these few species existing in the lakes of the interior, as well as from most of the species of fish now living in the Baltic. In general there can be recognized a close relationship with polar and arctic forms, even when the species are not the

same. In general, also, there is a diversity observable as regards the species living on the western side of Norway. From this, as well as from the difference of the testacea, which are met with in the older deposits, Lovén has very justly inferred that the basin of the Baltic was once connected with the Arctic ocean by an arm stretching eastwardly over Lakes Ladoga and Onega to the White sea, but was, on the other hand, separated by a narrow strip of land or isthmus from the western ocean, with which it now communicates through the sound. This separation must first have taken place when the glacial sea was on the retreat. Testaceous beds are met within the region of the eastern sea at an elevation of 130 feet, and these correspond in some species with the arctic character. But, as Lovén properly remarks, the fortunes of the glacial fauna of the east differed from those of the same fauna in the west. The basin of the Baltic was by degrees wholly separated from the polar seas, and the water, by progressive freshening and depression, became more and more unsuitable for arctic life; while, at the west, the sea surrounding the southern coasts of Norway stood constantly in open connection with the Arctic ocean, yet gradually acquired during the retreat a higher temperature, so that the northern fauna was driven thence, and was replaced by southern forms. This substitution did not take place in the Baltic. The opening of the sound at a later period brought into that basin no new species from the western sea. The Baltic basin, therefore, grew poor through the deperdition of unreplaced species; while the western sea, by the accession of the fauna belonging to warmer waters, acquired new affluence.

Middle Europe also has had its glacial era. On both sides of the Alps, in the Vosges and the Black forest, in the Pyrenees and other great mountain ranges of Europe and lesser Asia, the stone barriers and erratic blocks, the rolled pebbles, the polished and grooved rocks, which speak so plainly of glacier action, have been pointed out.

At the time of the so-called reindeer epoch, an advance of the glaciers took place for the second time, and this in consequence of a great inundation which was slow in attaining its ultimate limits. By this incursion, most of the low-lying tracts of Europe were laid under water. In Belgium, according to Dupont, the flood must have reached a height of 450 feet. To this inundation are to be ascribed the masses of gravelly clay, or calcareous mud, which have covered a part of France and Belgium.

The cold during this new overflow must again have become intense, but not so formidable as during the great glacial era. As most caverns were submerged, and men were forced to withdraw into the more elevated regions, a chasm presents itself in the paleo-archeological documents of this period, which, from the indications we possess, embraced several thousand years. Glaciers are not suddenly melted; valleys do not soon become filled with alluvium reaching to a height of some hundreds of feet on their side-walls; tracts of country and mountain chains cannot be heaved, at a jerk, as it were, into the air and raised high above their previous level. Processes of this sort require time, much time; and it is only by slow degrees that a state of great refrigeration, even when its causes have ceased, is transmuted into one of warmth and comfort.

After the final retreat of the waters, the caves would again come into the possession of men, and numerous and valuable proofs of human industry be prepared, which have been preserved even to the present time.

Here commences the true reindeer era. The reindeer, as the most characteristic representative of the northern fauna, had, beyond a doubt, inhabited, with the cave-bear and mammoth, the south of France. But it is at this period that it first makes its appearance in great numbers. It now spread in large herds as far as the Pyrenees, leaving no grounds for supposing that it had been introduced by man and kept in ancient folds. On the contrary, it lived here in its wild and naturally free condition. The last mammoths were yet alive, as

were also the rhinoceros and the great tiger. But the hyenas and the cave-bears existed no longer in middle Europe. An entire fauna of the larger animals becomes extinct, and man witnesses its disappearance from the earth.

The anthropological facts which we possess in regard to this far distant time are of course not very numerous, but not the less do they enable science to gather the general characteristics of the human race which lived at the reindeer era and in the period of stone implements which followed it. The stature of that race was small and the head round, (brachycephalous,) the face broad and square, the hair black.* The skull was usually thicker than with men of the present day. Nor is there anything which announces that the people of the reindeer era were particularly intellectual. From negative proofs it may be inferred that man at that remote period believed in another life, but there is nothing on which we can found an inquiry as to forms of worship. We find no figures or symbols which point to a veneration of idols. There has, indeed, been discovered a rude figure of a woman, carved on an elephant's tooth, but the idolatrous destination of this relic is not generally recognized. But while no religious idea can well be attached to it, it affords a proof that an advance had been made in art, which we cannot but consider highly creditable for this dawn of its development. The Marquis de Vibraye, to whom we owe this discovery, remarks:

> The man of the earliest age makes himself known through his works; he connects himself through his relics with the extinct animals; and finally becomes the revealer of his own existence by bequeathing us a representation of his corporeal figure.

Besides this rude female image, there is also a naked human figure, which seems to bear a staff on the shoulder, that has come down to us on a piece of reindeer's horn. The meagreness of the haunches and thighs, the prominent belly, somewhat reminds us of that type of Australian savages which we have learned to recognize from frequent representations by travellers, as for instance, from the atlas annexed to the voyage of Dumout d'Urville. The head is delineated only by a circular line. Accompanying this figure are two horses' heads, the neck of one horse being partially veiled by the human form, which again is closely followed by what is apparently intended to represent a reptile of considerable length, perhaps a serpent, but, judging from the shape of the head, body, and tail, with some traces of fins, more probably a large eel trailed along by the person in advance.

To the human figures in question is limited the personal representation which has so far descended to us, of the race of men living at the period of their execution, and it may well be supposed that they afford imperfect grounds for ethnological deductions. Yet, rude as they are, they do not want a certain interest arising from the consideration that in presenting the human form entirely nude, they may, perhaps, indicate that such was the habitual condition of that ancient population, an inference which the climate of the south of France, at least in summer, would render credible.

The discovery at Aurignac has already initiated us into the burial rites of the oldest known period of our race, nor had the man of the reindeer age changed the ceremonial which tradition had handed down to him. The grotto of Frontal at Furfooz, in the neighborhood of Dimant, disclosed very nearly the same peculiarities as the sepulchral cavern of Aurignac. The remains of thirteen human bodies, thrown one upon another by the floods of the diluvial era, have been here discovered at a depth of 51 feet under the gravel, and at an elevation of 390 feet. The entrance of the grotto had been originally closed with a flat stone, but this barrier has been destroyed by the irruptive waters. Two skulls only remain entire; as yet, however, the conclusions to which these curious relics of

*This round-headed race disappeared in great part after the immigration of the Aryschen race (dolichocephalous or oval-headed) from Asia, but it has not wholly perished. According to Nicolucci, it is still found in Hungary (the Magyars,) in Liguria, in the country of the Basques, in Finland, Lapland, &c.

the antideluvian era may conduct us, have not been discussed. According to Beneden and Dupont, there is a great difference between the two remaining skulls: the one is orthognathous, that is to say, with the teeth and bones of the chin in a right line, while the other is prognathous, having the jaws and teeth projecting; still the latter is said to have a higher forehead, and the cavity of the skull a greater capacity. Together with these remains was found an urn, which, unfortunately, is broken to pieces. In this we have the oldest extant specimen of the yet infant art of pottery. This burial vault contains, besides the above objects, instruments of stone, an awl and needle of bone, an arrow point and an articulation of the foot, which has evidently been wrought into some instrument. Thus it appears that the men of the reindeer period, like those of the age of the cave-bear, were accustomed to deposit with their dead objects of industry and ornament, which the deceased had doubtless been in the habit of using. As regards the bones of foxes, goats, and wild boars, which are also present, it is uncertain whether they have been borne hither by floods or are the remains of offerings which, as at Aurignac, have been set apart for the deceased. In the wide space before this cavernous sepulchre have been found numerous implements of stone and reindeer's horn, and, moreover, traces of a hearth, which probably indicates that a funeral feast had been held at the entrance of the cavern.

The people of the reindeer era were not acquainted with husbandry, and as little with the domestication of animals.* No instruments for fishing have been recognized. If the weapons of the age were still imperfect, they answered all necessary purposes, for we have already had occasion to notice the skill with which barbarous races of men contrive, with but rude instruments, to slay the swiftest and fiercest animals.

The beasts which lived cotemporaneously with man were, at this period, besides the reindeer, which had now attained its widest distribution through middle Europe, the following: the aurochs *(Bison europæus,)* the horse, which has improperly been regarded as differing from that of the present day, the primeval ox *(Urus primigenius,)* the musk-ox *(Bos moschatus,)* the deer with collossal antlers *(Megaceros hibernicus,)* the elk *(Cervus alces,)* the roe-buck *(Cervus dama,)* the wild goat, the chamois, the wild boar, which was either rare or its flesh not eaten, the glutton, the beaver, lemming, a species of hare, *(Lagomys,)* and the marmot. Among birds, we may mention the great auk, the heath cock, the moor-hen, the snowy owl, &c. It affords an argument for the prevalence of a great degree of cold in our region at the time in question, that the greater part of the animals just cited live most generally at the present day in high northern latitudes, or on the snow-covered peaks of the Pyrenees and Alps. The musk-ox descends in America only to the parallel of 60°, and habitually frequents the limits of perpetual snow.

In this reindeer period, the use of metals was unknown. Mankind continued to avail themselves of stone for the construction of their implements, though, together with this, they occasionally employed bone, horn, and ivory. There is evidence that the commerce of men at this time already extended to considerable distances. The population of Belgium, for instance, sought for silex in Champagne, which they might have found still nearer, in the vicinity of Maestricht and in Hainault. From this it may probably be inferred that, in certain directions, communication was attended with much difficulty. Bridges and artificial roads there were none, nor is there anything to show that resort was then had to

*A fragment of a reindeer's skull, which still contained the arrow-head of stone with which the animal was slain, shows that the reindeer was hunted as a beast of chase. It has also been observed that the cartilage was still attached to bones which have been thrown away by man after the extraction of the marrow, and that the edges of the fractures thereby occasioned are still sharp, which would not be the case if the dog had been at that time a domesticated animal.

boats for the passage of water-courses. Unwieldy rafts were seemingly the only means of conveyance when inundation or other exigencies stimulated the earliest attempts at navigation. To travel in unknown regions, standing thick with woods, where no trace marked out the way, was itself a circumstance well calculated to repress adventure; yet not the less did these Belgians hold communication with what is now known as Touraine, a fact which is satisfactorily proved to us by discoveries made in the cavern of Chaleux.

Human food was chiefly animal; the horse and reindeer furnished its principal staple. But the bison, the great ox, the goat, the chamois, were also eaten, and even the rhinoceros, when he could be mastered. The marrow and brain of animals were coveted as luxuries by a race, which did not, however, disdain the water rat, if the chase had been rewarded by nothing more acceptable. In the cave of Chaleux, Dupont found in the vicinity of the hearth more than 20 pounds weight of bones of the above animals, some of which had evidently undergone the action of fire. Yet, as the organization of the human frame is shown, even by its dental system, rather more adapted to a diet of fruits than of flesh, it may readily be supposed that this primitive people laid the forest under contribution for something more than its contingent of animals. Acorns and chestnuts at least must have entered into their dietary with the horse and reindeer, and while it would be vain to challenge any proof of this, it must be considered that such articles could not fail totally to disappear in the lapse of so many ages. It would be difficult, in the midst of our civilization, to form a conception of the uncleanly customs of this reindeer epoch, and, indeed, even of times still later. The bones left from their meals were carelessly thrown into the corners of the cave, filling it, of course, with putrescent miasmas. To find at present an analogous condition of things, we must go to the Esquimaux, who live towards the north pole. Like the latter, the people of whom we have been treating cared little for the accumulation of filth in their habitations, but here, at least, the winds had free access, and would, to some extent, expel the gases of decaying animal remains.

All caves in Belgium, France, England, &c., which were easily accessible, and provided with a sufficient opening, were inhabited. In the middle was the hearth, paved with sandstone or slate, and around this the family gathered during the season of intense cold. There were caves also, which being too much exposed to the weather, served only as a dwelling in summer. Such occur in the south of France, and are destitute of any traces of a hearth, though otherwise affording the clearest evidence of having been inhabited by men. Are we justified in concluding from this, as Professor Owen has done in regard to the inhabitants of the cave of Bruniquel, that mankind in the reindeer era devoured the flesh of animals raw? It is not, however, in caves alone that we find traces of the habitation of men. Numerous dwelling-places have been recognized, especially in Perigord, which were established under the open sky, in the neighborhood of water-courses, and sheltered by a sloping bank or overhanging rock. Here have been detected layers of ashes, bones which have been crushed, weapons, implements, and even the crude essays of a primitive art.

For clothing, at this era, man had recourse to the skins of animals. That these were stripped off for this purpose there is, singularly enough, adequate evidence still in existence. Incisions made in certain bones, and particularly in the skulls of reindeers close to the antlers, can only be supposed to have proceeded from the act of flaying. Numerous instruments everywhere collected, and which could have served for nothing else but scraping, show that the hair was in some cases removed from the skin. Means were probably known for making the hide pliable, so that it might serve for clothing in summer, while for winter vesture the fur would be preserved. We can of course know nothing as to the fashion in which the man of the reindeer age shaped this clothing, but we are at least certain that sewing was employed in preparing it. Bodkins or awls for making holes in the hides are not of rare occurrence, and needles furnished with an eye

testify plainly enough to the practice of sewing. We know also that for thread the sinews of ruminating animals, especially the reindeer, were employed. The long shank-bones of these beasts often present a transverse incision, just at the point where the lower end of the great tendon is inserted.

It may appear somewhat surprising that a taste for personal adornment should have insinuated itself among the hard necessities of such a state of existence; yet such a taste there was, if of a very humble description. Bracelets and necklaces were then worn, sometimes composed of strings of shells, as well of fossil as still surviving species, sometimes of the teeth of different animals. The ivory-like part of the ear-bone of the horse is also found pierced, probably with a view to being worn on the neck. The canine teeth of the greater carnivori (tiger, wolf, lynx) were often pierced for the same purpose. On the tooth of a bear has even been found the carved representation of a bird's head. In fine, from the old dwelling sites of this period have been gathered pieces of fluor-spar, jet, silex, and copper ore, all alike perforated in the centre, besides other objects which have a semblance of having served as amulets. The cave of Chaleux, near Dinant, in Westphalia, has furnished 54 shells of fossil testacea, which it is clear can only have been brought from Champagne, where it is probable they were picked up by the ancient Belgians when they resorted thither for silex. Most of these shells have the central perforation, which denotes their destination for the toilet; no very costly ornamentation, it is true, but something foreign and exclusive, and not to be obtained by everybody.

The weapons and implements were in the reindeer period of an improved construction when compared with those of the age of the cave-bears. The weapons consisted of lances and javelins, but the stone points of these were more finely cut. The arrow-head of stone, without barbs, was not discarded, but a preference was given to arrows made from bone, or the horn of the stag and reindeer, and elaborated with more art and diligence than those of stone. Some of these have been found, which are furnished with barbs on both sides, and specimens occur in which the barbs are hollowed out, as if for reception of a poisonous substance. The number of barbs is from four to six, ranged alternately on either side. Lartet has discovered in Perigord a dagger of reindeer's horn, on the hilt of which is to be seen the rudely carved image of a reindeer. The points of arrows and lances thus furnished with barbs may have served alike for the chase and for fishing. We know that in the hands of the South Sea islanders and the Esquimaux these barbed points, however clumsy they may seem, are no despicable weapons on land or in water.

Very numerous are the utensils and implements found in the caves and at other primeval dwelling sites of Perigord and Belgium. First among them may be mentioned small saws, being plates of flint, dexterously notched or dentated along the edge. This instrument was used to divide the antlers of the reindeer, a circular incision being made with it in the horn, which was then broken. Knives or blades of flint, generally small ones, are everywhere plentiful, as are also implements for scraping. The stone hatchets, on the other hand, have almost disappeared. A block of quartz has been found, which probably served as an anvil, for it still bears the trace of blows with the hammer. Among objects prepared from other substances we distinguish awls of bone and needles of bone, horn and ivory. Both instruments have been found in different places. There are, besides, instruments for smoothing, such as are in use among the Esquimaux to press the seams of the skins worn for clothing. Spoons of bone or horn also occur, set off with a certain primitive ornamentation, and used probably to extract the marrow from bones. We find, further, hunting whistles pierced with a round hole, and formed from the first joint of a deer's foot; also knuckle-bones, used, as now, in sports and games, together with many other objects, whose purpose has not been determined.

Among the stone instruments particularly worthy of note are the augers or

gimlets which were employed to bore larger or smaller holes in bone or horn. When teeth and bones were first found, now presenting needles pierced with a small eye, and again containing holes as much as an inch in diameter, and these quite round and thoroughly perforated, explorers attempted to produce similar holes with the usual stone implements; but in vain: the points splintered, and no such hole could be wrought. There were English philosophers who asserted, especially in view of these failures, that perforations of this sort could not be made without metal. Now, M. Lartet has discovered certain implements of flint, large as well as small, whose points, instead of being made sharp, are roughly cut, so as to form angles not unlike those of a crystal. It occurred to him that these had served for drilling the holes in question. He therefore fixed one of these pieces in the cleft of a stick split for the purpose, and by dint of turning it between both hands to and fro, found that it performed the work of boring with great success. The communication of this fact has satisfied scepticism as to the destination of these instruments, which are found in considerable quantities and of different sizes.

At Tayac and Eizies have been found pieces of quartz, either round or quadrangular, which have been hollowed out in the middle. M. de Vibraye conjectures that they were used for grinding grain, but most of them are too small to have served for this purpose. M. Lartet is of opinion that they were made use of in kindling dry wood by rapid attrition.

The people of the reindeer era manufactured by hand, and without the help of the potter's wheel, a sort of rude earthenware of a black, gray, and yellow color, all tinged more or less with red. The clay was commonly mixed with quartzose sand, the better to withstand the action of fire. A circular mark formed the sole ornament. These imperfectly baked vessels, of which only fragments have been found, are not, however, the oldest specimens of the fictile art in existence. Traces of it have already been discovered in three grottoes of the age of the cave-bears. In the earliest times man would feel the necessity of providing a supply of water in his cavernous dwelling. A cavity in a mass of clay would be the receptacle of the water brought in skins from the brook. To render the utensil lighter, superfluous parts would be removed, and it would be dried in the sun, in order to harden it. Still later, man learned to mould rude vessels, which he exposed to the heat of the hearth to procure a degree of hardness greater than that produced by the sun's rays. Such were the humble beginnings of an art whose finished performances surprise and delight us in the fabrics of Dresden and Sevres.

III. It is now known that the populations of the reindeer era were not wholly destitute of a certain plastic culture and of the art of delineation. If the forms of most of the instruments of horn which have been found are susceptible of explanation from the necessities of common life, and from the instruments which have been used at later periods, such is not the case with a class of objects whose signification and use had not heretofore been unriddled. These consist for the most part of the entire stem of a reindeer's antler, frequently with one or more prongs, especially that next the root, always smoothly polished, and at times charged with a simple linear ornamentation. But in the generality of cases these stems, more than a foot in length, are furnished with holes, which, to the number sometimes of four, are seen ranged one after the other, while the whole length of the stem is ornamented with curiously carved lines and figures, among which horses and reindeers are particularly numerous. In the International Exposition of 1861, among the objects sent by the savages of Vancouver, figured just such a staff, polished and bearing engraved lines; probably an ensign of command or rank. Might we not assign to the ancient staff the same signification, and consider the holes and figures as bearing, in their number and size, some relation to the circumstances of the owner?

We have thus arrived at the most striking of these relics of a remote antiquity,

for from no other source probably can we derive such distinct ideas of the life and habits of the reindeer hunters of southern France as from the remarkable representations of the animal world which we find engraved chiefly on these remnants of reindeer horn, but sometimes also on pieces of bone, ivory, or slate. Thus far, indeed, and until further indications offer themselves, we must ascribe the practice of this primitive art solely to the population who, within a circumscribed space, inhabited Dordogne. The representation of real objects for the purpose of ornament is, in this case, the more remarkable, inasmuch as in far later times, those namely of the pile-constructions of Switzerland and the stone age of Denmark, no trace of such an application of art is to be met with; on the other hand, however, indicative in form of a certain degree of taste, the ornamentation of these later ages is altogether confined to a combination of different lines, of angles, circles, zigzags, &c., and never consists in an imitation of either animals or plants. We should certainly have obtained a much clearer knowledge of the social condition of men in the time of the pile-structures if we possessed in reference thereto representations similar to those which the reindeer caves of Dordogne have supplied; for if these convey to a certain extent illustrations of the hunter and fisher life, the pile-builders, had their art taken the same direction, would doubtless have bequeathed to us images, carved upon horn or other material, illustrative of their husbandry and domestic industry. This difference can perhaps only be accounted for through the original genius of the races, as it can hardly be supposed that in the narrow district of Perigord a particular population should have flourished, together with the whole northern fauna, as it were upon an island, and only at a later period attained that higher degree of art which distinguished it; and the less, as cotemporary deposits from other caves show nothing of the sort. Thus the museum in Geneva contains a truncheon of horn from a grotto at Saléve, which marks the eastern point of the reindeer caves; and this instrument, while it is bored through the end, and the general workmanship is the same as in Perigord, nowhere exhibits any other than the common linear ornamentation of the period.

It is a fact worthy of note that in all the figures yet found, no plants, but only animals, are represented. This circumstance may not be without its significance in the absence of all proofs of a vegetable diet on the part of these huntsmen of the reindeer era. Yet it is to be observed that this defect of vegetable forms plainly harmonizes with a certain vivid feeling of the artists for the representation of movement. Animals stationary or in repose are extremely rare. Reindeers, as well as other animals of the deer species, are shown in rapid flight, as testified by the head bowed back upon the neck, the outstretched legs, sometimes by the gaping mouth and panting nostrils; at other times they are represented in the act of springing, with the fore legs bent back beneath the body, the hinder legs stretched stiffly out behind. The climax of this infant art seems to have been reached on a sheet of slate in the possession of the Marquis of Vibraye, which is plainly intended to represent a group of fighting reindeers. One of these struggles while lying on its back with its legs in the air; another draws itself together as in the act of onset; a third, with head sunk down, has evidently just overthrown the first.

Assuredly we do not mean to claim for these delineations anything like uniform merit, or an exact appreciation of characteristic peculiarities; the figures present sometimes but a stiff and wooden appearance, and we are even left in doubt whether we have before us an ox, a horse, or a reindeer. It is, however, but just to say that such enigmatical figures are fragmentary only, and we should doubtlessly recognize them more readily if the picture had remained entire. Most of the figures, on the other hand, evince no mean facility of the artist in seizing on distinctive traits, so as to enable us at the first glance to determine the species; though, of course, there can be no question here of finished execution, but merely of a successful rendering of the most essential details; the characteristic outline

conveyed in a few simple strokes. The reindeer, horse, bison, steinbock, elephant, are not to be mistaken, and even the peculiar mode of movement of each of these animals is rendered with great truth. In these cases a certain freedom of execution is often exhibited which could only have been acquired by much practice. Now, it is precisely this freedom in the representation of motion which has inspired many with doubt as regards the authenticity of these relics; it indicates, they argue, an advanced stage of art, long observation, and persevering practice of the eye and hand, to render such representation possible, and if the saints and madonnas of the first Christians are commonly stiff and clumsy, certainly the products of prehistoric art must be expected to betray this character. Admitting these views to be somewhat plausible, we may yet venture to oppose to them the fact that the earliest attempts of Greek sculpture are particularly distinguished by the characteristic conception of motion; that in the group of the Æginetes, for instance, the movements of the figures in battle are rendered with great felicity, while the expression of the faces is wholly slighted. It is altogether the same in the present instance. The art of the reindeer period had advanced so far as to be capable of manufacturing a stone dagger whose hilt represents a reindeer in the act of springing; the horns and extremities are creditably executed, and the movement is perfectly represented; but the skill of the artist has failed in giving an expression of reality to minuter features.

It may be regarded as characteristic also that these representations, where they occur on fragments of some size, always place before us a number of animals of the same species, and disposed in such a manner as is usual when they move in herds, being sometimes wide apart, and sometimes so closely crowded that the body of one covers more or less that of another. Since attention was paid to this rule of representation, it has been observed that, on the celebrated mammoth piece hereafter to be noticed, there are certain strokes which, besides the principal animal, indicate two others of the same species.

If these representations are in themselves highly worthy of our attention as art-productions of the earliest times, they are even more so in reference to the objects represented, for these afford us a criterion of the methods of inquiry heretofore followed in regard to the animal bones which have been exhumed from the caves. To many, who want confidence in the rigorous procedures of comparative anatomy, it may perhaps have seemed presumptuous that a savant, having before him only a joint of the foot, the end of a bone or a tooth, should pronounce authoritatively that here a reindeer and not a hart, that there a bison and not a common ox, has existed; but when, as now, a verification is afforded by an exhibition of the entire animal form in its sculptured representative, when it results from this that he who carved it on the horn must have known the animal, and accurately known it, in order to portray it in its proper shape, all doubt must vanish. The bones of the reindeer and bison could not have been washed hither in a deluge from the far north and deposited in the southern cavern, as has been pretended; the animal must there have lived in its flesh and blood where to-day we find its bones and its sculptured figure. Let us see what were the species known at present to have been thus represented.

Among these the reindeer is by far the most frequent, while its antlers have in great part furnished the material on which the representation is carved. The form of the head and horns and the hair of the neck leave no doubt in the determination of the species. The stag, which occurs more seldom, admits of easy discrimination. Next follows the horse, evidently of a race with short, thick head, short neck, compact body, strikingly similar to the northern race of our own times. He that has once seen the Iceland horse, as it roams at large in its native island, will here instantly recognize the original pattern.

On the piece on which is represented the man with horses and an eel, we see on the other side two heads of bisons, which are perfectly characterized by the profile of the forehead, the insertion and curvature of the short horns, and the

profuse crinosity of the neck and head. The bison or aurochs therefore flourished here in companionship with man, the horse, and the reindeer. Another figure, which unfortunately is mutilated, but is distinguished by the fineness of its hair, seems to point to another of the bovine species differing from the bison; nor is this a matter of surprise, since the testimony of the bones is to the same effect. An animal of the goat kind, probably the steinbock, is not wanting, while some other figures of horned and graminivorous species must be acknowledged to be deficient in point of distinctness.

The most remarkable relic, however, is the representation of the primeval elephant, a real mammoth, on a plate of ivory, which formed part of a tusk of large dimensions. In May, 1846, M. Lartet, in company with Dr. Falconer and Verneuil, both well-known naturalists, caused excavations to be made in the stratum of the cavern of the Madelaine. "At the moment of our arrival," says Lartet, "the laborers disinterred five fragments of a rather thick plate of ivory, which must have been detached, ages before, from a large tusk. After having fitted the pieces together by their corresponding edges, I pointed out to Dr. Falconer numerous scratches and lines somewhat deeply engraved, which, on collocation, constituted an animal figure. The practiced eye of the distinguished paleontologist, better versed than any one else in the study of elephantine animals, at once recognized the head of an elephant. He then directed our attention to the other parts of the body, and especially to certain tufted lines in the region of the neck, denoting the characteristic mane of the mammoth or elephant of the glacial era. It is generally known that this peculiarity which marks the arctic habitat of the animal, was verified, in the year 17?9, by Adams, a member of the Academy of St. Petersburg, in the carcass of such an elephant, found imbedded in ice near the mouth of the Lena. A bunch of its hair is still to be seen in the geological collection of the Garden of Plants at Paris.

"I have shown the piece in question to competent observers, such as Milne Edwards, de Quatrefages, Desnoyers Longpérier, and Franks, director of the London Antiquarian Collection; and the latter has, by means of the pencil, rendered the characteristic lines more distinct in the plaster cast which had been taken of the object.

"This new fact only tends to strengthen the conviction already acquired of the existence of man at the same time with the mammoth and the other large graminivorous and carnivorous beasts which, according to the geologists, lived in the first section of the quaternary period. The truth of this historical fact results from so many concurrent observations and from material facts of such plain import, that even the most prejudiced cannot fail to recognize its entire validity, if they will permit themselves to see and judge with ordinary conscientiousness."

The elephant, thickly clad with hair on the neck, forehead, and breast, is seen in profile and at its full length in the act of striding forward. At first it was not rightly known what was to be made of a tuft of hair and certain marks which are seen to the left in advance of the line which forms the profile of the forehead. Repeated and closer scrutiny of the fragment has enabled us, in the end, to recognize therein the eye, the outline of the forehead, together with the proboscis of a second elephant, which is advancing close by the side of the first. Some lines on the leg would lead us to conjecture a third elephant, which followed on the part of the plate which is broken off. The drawing of the figures is executed with a free and bold hand, and the characteristic movement of the elephant, which raises simultaneously the legs of the same side, is well preserved.

Another memorial of the art of this ancient epoch is an elephant's head carved on a reindeer's horn, which was also discovered in Perigord by the Marquis de Vibraye. These two relics are the more interesting as furnishing the proof that man actually existed as the cotemporary of the mammoth or gigantic elephant, a fact which has been so often and so obstinately contested. But since the localities where these objects of primitive art have been found unquestionably belong

to the reindeer period, it is conclusively shown that some of the mammoth species survived to that time.

It is rather remarkable that as yet only a single delineation has been found which can be interpreted as relating to the bear, being the head of that animal, while the rest of the carnivora are wholly unrepresented. That representations of the unavoidable struggles of man with these animals should not have been left behind is scarcely to be believed, especially when their teeth, pierced with holes and destined for suspension as trophies, bear unequivocal testimony to such encounters. Birds and reptiles have not hitherto been found represented. Fish, on the other hand, are very frequent, and can, for the most part, be recognized as belonging to the carp family, which still frequents the fresh waters of the region. We meet with no trace of marine animals; the men who lived in Dordogne at the era of the reindeer seem to have known nothing of the sea and its inhabitants.

These objects of art have been found only in the three grottos of *Les Eyzies*, *Laugerie-Basse*, and La Madelaine, in the department of Dordogne. The first of these is high and wide enough to enable the light to penetrate throughout, being 12 metres deep, 16 broad, and 6 metres high; it appears to have been used in the middle ages as a stable for horses. When Lartet and Christy began their explorations, the grotto had been considerably enlarged and deepened by earlier occupants, though the explorers found at the bottom a compact floor, from which projected masses of blackish stalagmite, flint instruments, stones, and pieces of bone; this bone-breccia lay immediately on the rock floor of the cave, and showed a thickness of one to three decimetres. Large pieces were broken loose, which were sent partly to different museums, but in greater quantity to Paris, with a view to more exact examination. The station of Laugerie-Basse is partly in the hollow of a rock, whose face is 100 feet high, while a part of the formation, on which appeared traces of an ancient fire-place, extended outwardly in front of the cavern. Within, the breccia was full three metres in depth. The neighboring station of the Madelaine lies at the foot of the rock, and forms a decayed heap 15 metres in length, 7 in breadth, and 3 in depth, in which some human bones were found, but unfortunately not complete enough to indicate the race of men from whom they proceeded. Some fragments of bloodstone and a coarse stick or pencil of ochre leave it to be inferred that in that distant age colored drawings were sometimes executed.

Thus we see how civilization was undergoing a slow but constant development among the oldest inhabitants of middle Europe. The facts which the excavations of Chaleux have disclosed, in connection with those discovered in the grottos of Furfooz, furnish a picture of the first age of mankind in Belgium. These old populations, with all their usages, reappear before us, after having been many thousand years forgotten, reminding us of the fabulous bird which sprang with renewed life from its ashes. So the primeval age of mankind is rebuilt from its own ruins.

We see them in their dark, underground retreats surrounding the primitive hearth, shaping with some skill and greater patience their weapons from flintstone and their utensils from reindeer's horn, in the midst of the unwholesome exhalations of animal remains, which in their carelessness they have heaped around them. The skins of captured beasts are stript of hair, and from these clothing is prepared by means of an awl of silex and a needle of bone. We see them armed with arrows and lances, whose points of flint have been sharpened for deadly execution, pursuing the beasts of the waste. We visit them in their fastnesses, where a horse, a bear, a reindeer, forms the product of a successful chase, and the repulsive flesh of rats their resource against contingent famine. They conduct a commerce with the populations of France, and bring thence molluscous shells and jet, with which they delight to adorn themselves, and silex, which is so indispensable for arms and implements. Here is a store of fluor-

spar, whose colors beguile their fancy with a show of luxury, and there the wide plate of sandstone destined for paving around the hearth.

But there come days of disaster, and truly disaster is not spared them. A concussion, a sudden downfall drives them from their rocky dwelling. The objects of their veneration, their utensils, are alike shattered, and they are cast forth to seek for some other shelter. Or death invades them with its desolations, and what pious cares do they then consecrate to those whom they have lost! We see that they lay the body away in a cave; an urn, weapons, amulets, constitute the equipment for the vault. A broad plate of stone guards against the entrance of wild beasts. Then begins the funeral feast in the immediate vicinity of the sepulchre; fire is kindled on the hearth, large animals are dismembered, and the roasted flesh is distributed among the guests. There are no doubt other strange ceremonies practised, as is now the custom with the rude tribes of America and Africa, but these we can only conjecture. Analogy would point to songs, dances, adjurations, but science can afford us here not the slightest information. Again and often will this vault open, and small children, as well as men of full stature, take, one after another, their place in the cavern amidst the same ceremonies.

But the end of this oldest of known epochs is at hand. Floods overwhelm the region. The dwellers, driven from their caves, seek refuge in vain on the hills. Death overtakes them; a dark grotto becomes the grave of those hapless fugitives who, as at Furfooz, were witnesses of this great catastrophe. Nothing is spared by the fearful element. The sepulchral caverns, the objects of a touching solicitude on the part of these poor people, are forced open by torrents of water, and the bones of the dead are generally scattered abroad. Only the dwelling-place of Chaleux is exempt from the ruin; it is protected by an earlier catastrophe. This consisted in the downfall of the roof of the cavern.

Lucky and multifarious discoveries have conducted us to these results. The usages and industry of these tribes, which reach back to so distant an antiquity, can be pictured with some exactness. But much yet lies in darkness. We know nothing of their relations to the people of earlier times. Had they predecessors in the land? The important discoveries which Schmerling and Prof. Malaise have made at Engihoul seem to show that the men whose remains were found on the Lys were not the aboriginal inhabitants of Belgium, but only successors of an older population. At Chaleux also were found substantial indications of that primeval ancestry, but the traces were scarcely discerned when they were again lost.

Besides the three stations above named, a large number of caves have been discovered in France and Belgium, which everywhere contained the bones of the same animals. Among these, the reindeer plays the principal part, and is always accompanied by the horse, the steinbock, the chamois, and the bison. The remains of the mammoth, rhinoceros, wolf, brown bear, lynx, glutton, sheep, marmot, and common deer, are seldom found; still more seldom those of the hyena, the tiger, the porcupine; while the bones of birds and fresh-water fishes, which we need not enumerate, occur in abundance.

In the cavern of Bruniquel were found, by its owner, 1,500 different objects, which were all purchased by Professor Owen for the British Museum. Here were also discovered human remains, especially a jaw bone. The cavern of Chaleux, in the valley of the Lys and neighborhood of Dinant, presents a remarkable peculiarity, an analogue, so to say, of Pompeii and Herculaneum, cities which Vesuvius did not destroy, but has preserved for us. All the objects contained in the cavern, just as it was occupied at the time, have, as already mentioned, been kept entire by the downfall of its roof. The rubbish, under which the various articles lay buried, has prevented the destructive effects of the diluvial currents. After the removal of eight feet of compact detritus, the proper floor of the cavern, upon which man had resided, was reached. Probably the inhabitants were absent on the chase at the occurrence of the catastrophe, for no human

bones have been found here, but some 3,000 implements of flint, as well as others of bone and reindeer's horn have been recovered. The hearth, paved with flat stones, lay in the middle of the cave, and on it were still found coals and ashes.

However incomplete may be the results thus far obtained, they still show in the most conclusive manner the correctness of the deductions which have been drawn from them. The remains which have descended to us undoubtedly present many a riddle, but we should not despair of their ultimate solution. Perhaps a fortunate incident may bring us, sooner than we think, the desired explanation.

In conclusion, we should say something respecting the animals which, in that distant age, lived as the cotemporaries of man. The cave bear, *(Ursus spelæus,)* according to Owen and Pomel, first made its appearance in England and at Champeix in Auvergne, towards the end of the tertiary epoch. If all the determinations are correct, its remains have been found in Siberia, Scania, France, Belgium, England, and Germany. The cave bear was the largest of the species known, and seems to have become extinct before the reindeer era.

The mammoth *(Elephas primigenius)* was living in middle Asia about the end of the tertiary epoch, but in Europe its remains are first found in the quaternary formations. It has inhabited a wide geographical zone, for it spread from Sicily to England, but to the south it extended not beyond central Italy and the Pyrenees. In Italy and southern France it seems to have survived during a part of the reindeer period, while further to the north it had disappeared.

The rhinoceros lived almost universally in company with the mammoth, and became extinct during the reindeer age. It is generally known that a carcass of this rhinoceros was preserved, together with a mammoth, for many thousand years in the ice of Siberia. When discovered, they were found to be still furnished with both hide and hair.

The cave hyena *(Hyæna spelæa)* was, during the quaternary epoch, of very frequent occurrence in Europe. It is commonly supposed to have belonged to one of the two different African species still surviving. Thus far, traces of this animal have only been found in the pliocene or upper tertiary deposits, and it seems to have lived neither in Spain, the south of Italy, nor in Sicily. The cave hyena became extinct during the reindeer period, and in Belgium even before that era.

The gigantic cat of the caves, *(Felis spelæa,)* whether tiger or lion, a point very difficult to be decided from the parts of the skeleton found in those repositories, makes its appearance only with the quaternary period, and seems to have disappeared with the same. The reindeer period reveals some traces of it, and this indicates that the feline tenant of the caves had not then disappeared, like its cotemporary, the cave bear. Lartet even asks whether the former, like the aurochs, while withdrawing further to the east, did not survive within the period of history. In fact, the lion of Thessaly, spoken of by Herodotus, and which is figured on Grecian coins, endured a climate like our own, and could not therefore be the present African species. Dr. Falconer has gone even further: in his opinion the great feline animal which subsists on the slopes of the Altai and in the north of China, and which is generally supposed to be identical with the Bengal tiger, may well be the *Felis spelæa*, which, by reason of the increase of mankind and the development of civilization, has retreated into the deeper recesses of Asia.

The gigantic deer was chiefly an inhabitant of England and Ireland. A complete and very fine specimen of it may be seen in the British Museum. Its remains are met with, but not very frequently, in France as far as the Pyrenees, in Germany and the north of Italy. This animal existed as early as the pliocene era, and became extinct during the reindeer period. Its horns measured from 10 to 11 feet in breadth. It has been improperly called the deer of the peat moors, since, at the time when these moors were formed, it no longer existed.

The reindeer *(Cervus tarandus)* made its appearance with the mammoth in middle Europe, and hence at the beginning of the quaternary period. Its remains, which occur so abundantly in the caves and other sites where man has dwelt, testify to a vast numerical development at the epoch to which the animal has given its name. This circumstance enables us in some measure to account for the rare occurrence of the ure ox and the deer, for it is known that both these animals entertain a great antipathy for the reindeer. Where the latter has rested, the former avoid feeding. The reindeer, whose geographical habitat extended to the Pyrenees, withdraws towards the north and disappears in middle Europe at the period of the last great movement of the waters and of the red diluvium. At the epoch of the peat moors it no longer existed in France. At present it inhabits the coldest regions of northern Europe. The remains of the elk *(Cervus alces)* are seldom met with in the temperate European latitudes. It seems to have followed the reindeer in its migration to the north, where it now exclusively sojourns.

The aurochs *(Bison europæus.)* This wild ruminant seems to have existed in the pliocene period, and was very widely distributed in middle Europe. Its remains occur sparingly in the peat moors and in the pile settlements of Switzerland. Cæsar did not observe it in Gaul or in the Hercynian forest, but Pliny asserts that the bison, which could be none other than the aurochs, lived in Germany. The animal is now nearly extinct, being found only in Lithuania, where it is protected by stringent laws, and at Gervais, in the forests of the Caucasus.

The great ox, or ure ox, *(Bos primigenius,)* appears with the quaternary era, and attains so wide a geographical diffusion that its remains are found in the whole of Europe. It survived, like the aurochs, the ages of stone and bronze, and subsisted even in the age of iron. Cæsar mentions it in his commentaries, and the *Veson cornipotens* of the Chronicle of St. Gall (10th century) is, according to Steenstrup, nothing else than the *Urus* of Cæsar. The species is at present wholly extinct.

The musk ox, *(Bos moschatus,)* a smaller ruminant, is intermediate between the ox and the he-goat. It lived in France and England simultaneously with the cave-dwellers. Its remains are found in the flint formations of the diluvium. At present it lives only in the coldest regions of America.

The horse *(Equus adamiticus)* dates from the origin of the quaternary formations. It differs from the horse of the tertiary era, but seems identical with the now existing species, *(Equus caballus.)* In the age of the cave bears and the reindeer, the horse was very widely distributed through middle Europe, and furnished the populations of that time with their principal food. A smaller race is met with in the pile settlements of Switzerland and in the Pyrenees. It was at a later period that man availed himself of the horse for riding, especially in war. The Greeks seem first to have practised equitation about the seventh century B. C.

PHOTOCHEMISTRY.

By M. Jamin.

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Solar radiations, and in general those of all luminous bodies, are composed of a multitude of superposed vibrations endowed with very distinct properties, and which it is practicable to isolate by means of the prism. The first, and least refrangible, are obscure, and manifest themselves to our organs only by the calorific phenomena which they produce. These are followed by the luminous radiations which succeed one another from the extreme red to the ray H of the spectrum. To the violet rays, finally, succeeds a large number of radiations, invisible it is true, but whose existence is revealed by their power of effecting decompositions or chemical combinations.

I have heretofore insisted on the point that there were not three special classes of radiations superposed at a given point of the spectrum, and differing by their nature itself, but a single ray capable of possessing three properties—of being calorific, luminous, and actinometric. From one end of the spectrum to the other, the rays remain identical in their nature, but possessing increasing refrangibilities and vibratory velocities, more and more rapid. I have shown, by the phenomena of phosphorescence and fluorescence, that these different rays can be transformed one into the other. Thus, when luminous radiations, simple and well defined, fall on a metallic plate, they are at first absorbed by degrees; the plate grows warm; it then radiates in its turn, but gives out only obscure, that is to say, less refrangible, radiations. Thus again, in the curious phenomena of phosphorescence and fluorescence, we have seen that the ultra violet radiations, scarcely visible, were absorbed by different bodies, and became transformed finally into luminous radiations. In a word, different substances have the property of selecting and absorbing certain simple radiations in preference to others, of themselves entering into vibration, and of yielding up by radiation the active force absorbed, with this constant character, that a simple ray has been finally transformed into an assemblage of other mixed radiations, all less refrangible.

It is another form of this proposition which I am about to expound in the course of this lecture. I propose to show that the medium may retain the vibrations which it has absorbed, and that the active force which they have communicated to it, being incapable of being lost, is applied to the production of an equivalent chemical effect. It is with photochemistry, in a word, that we shall now occupy ourselves.

Scheele discovered, in 1770, that chloride of silver exposed to the light assumes a violet tint, but he did not stop there. Proceeding to inquire to what simple radiations this phenomenon was due, he studied it in the spectrum, and found that the violet rays were alone capable of producing it. He named them, on this account, *chemical rays*. Wollaston carefully repeated this experiment, and observed that there existed beyond the ultra violet radiations still other radiations, more refrangible and wholly invisible, but capable of acting on the chloride of silver.

This admirable discovery, which is the principle of all the phenomena of photochemistry, remained long unexplained, under the chemical point of view. The explanation was given by MM. Girard and Duvanne. These two chemists, having exposed chloride of silver to the solar rays, found that this blackened chloride was susceptible, in part, of being attacked, with disengagement of hyponitric acid, by nitric acid, a manifest proof of a partial reduction of the chloride into chlorine and into metallic silver under the influence of the light.

But this compound is not the only one in which this phenomenon is observed. Light acts as a reductive agent on the nitrate of silver, the chloride of gold, the chloride of platina, and in general on almost all the chlorides, bromides, and iodides of metals the least oxidizable. The same is the case with a great number of oxygenated metallic compounds. Every one knows that concentrated nitric acid, entirely colorless when exposed to the light, is quickly colored yellow, inconsiderable quantities of this acid becoming decomposed into hyponitric acid and oxygen. The same may be said of chromic acid, which undergoes a partial reduction, loses a certain quantity of oxygen, and is transformed into sesquioxyde of chromium.

In all these cases the light acts on the metallic compounds as an agent essentially reductive. We are now about to see this same agent, in another order of experiments, produce very varied oxidations, and favor combinations in general. Let us take, for instance, a mixture of chlorine and hydrogen, and expose this mixture, enclosed in a flask, either to the solar radiations or the brilliant flame of magnesium. A sharp detonation will immediately announce the instantaneous combination of these two gases in forming chlorhydric acid.

There is here, then, no longer an action of reduction, but an action of combination, which the light has exerted. The phenomenon is the same for all organic substances. We know, for example, that if hydrogenated compounds be exposed to the action of the sun in presence of chlorine or bromine, combinations are always formed in which the chlorine or bromine is substituted, equivalent by equivalent, for the hydrogen of the organic compound. This, in effect, is the starting point of the theory of substitutions devised by M. Dumas.. The process of bleaching cloths by exposing them to the sun is a phenomenon familiar to every one, and is also owing to a slow oxidation of the tissue.

Among these different examples of oxidation produced under the influence of light, there is one which it is especially incumbent on us to cite, because it has been rendered famous by an ingenious experiment, made in 1813, by Jean Nicéphore Niepce, an experiment which was in some sort the starting point of photography.

Nicéphore Niepce, having taken bitumen of India, (asphaltum,) dissolved it in oil of lavender, and was thus enabled to spread it on a plate of glass, which he exposed to the sun after having covered it with an engraving. Now, bitumen has the curious property of becoming insoluble in volatile oils when it has been for some time exposed to the light. This light penetrated to the bitumen through all the white parts of the engraving, but was arrested by the black lines; and by afterwards washing his plates with oil of lavender, M. Nicéphore Niepce obtained a reproduction of his engravings. The white parts therein were represented by the bitumen, now become insoluble and of a milky-white appearance, the parts from which the bitumen had been removed representing the black portions.

This experiment, as I have said, was the point of departure for photography. Still another example of these phenomena of oxidation remains to be noticed. It is afforded by the resin of guaiacum, which has the singular property of changing to a deep blue in the light at the same time that it is oxidized. If, therefore, it is dissolved in alcohol, and a sheet of paper be impregnated with it, we may obtain copies, as with the bitumen, by covering the paper with an engraving and exposing it to the sun; but as it remains white under the black

lines, and becomes a deep blue under the white, we obtain, in reality, an inverse image. This is a negative proof.

Thus we see that the solar radiations, in acting on different bodies, may give rise to two very distinct orders of chemical phenomena: phenomena of reduction in all the metallic compounds; oxidation, a tendency to favor combination, as regards all organic bodies.

If the opinions thus advanced are well founded, it is evident that by mixing with metallic salts organic substances we shall double the effects by augmenting the sensibility of the photochemic action. This may be demonstrated by numerous experiments. The following, which is one of the most decisive, we owe to M. Niepce de Saint Victor, nephew of the inventor of photography. He took a piece of porcelain presenting a fresh fracture and covered it with a solution of nitrate of silver; he then exposed it to the sun while screened from all organic matter. The nitrate of silver remained unaltered; but when a leaf of paper was imbued with this solution, or the nitrate of silver was mingled with any organic matter, (gelatine, tartaric acid, for example,) before covering the porcelain, the action of the solar rays was immediately manifested, and the silver was reduced to the metallic state. It is evident that in this experiment the active co-operation of the organic matter admits of no doubt.

We may further adduce an experiment of Professor Haghen, of Kœnigsburg, which leads to the same conclusions with the preceding. M. Haghen took two tubes and filled them, one with a solution of nitrate of uranium in distilled water, the other with an alcoholic solution of the same salt. The first of these tubes was carefully closed, to exclude the access of any organic matter; both were afterwards exposed to the sun, and, agreeably to M. Haghen's previsions, the second alone was altered and partially reduced. These results are constantly turned to advantage in the art of photography.

And, indeed, in the preparation of sensitive paper the only object in covering the sheet with a thin layer of choloride of silver is to bring together in a state of considerable division the reducible metallic salts and the organic matter destined to effect the reduction. It is proper, however, to add that, in order to still further augment the sensibility of the papers intended for photographic proofs, it is the practice to dip them, in the last place, in a solution of a chloride, a bromide, or an alkaline iodide.

The following will serve as a final example of the energetic part which organic substances play in these photochemic actions. About 1850, M. Poitevin, one of the most celebrated French photographers, took a salt of sesquioxide of iron, the sesquichloride, added to its solution an organic matter, and saturated some leaves of paper with this mixture. Under the influence of light and by virtue of the presence of organic matter this salt, which the light alone could not modify, was partially reduced, and passed to the state of a photochloride. In taking a photographic proof with such paper, it is sufficient, in order to make the image appear, to wash the sheet with a solution of cyanoferride of potassium or tannin. These compounds reacting only on the perchloride of iron wherever it has been preserved intact, that is to say, under the black portions, we obtain a positive proof, colored blue or black, according to the compound employed for washing.

I shall not further multiply these examples; but there is a fact of much more importance, and to which I proceed to call your attention for a moment: I refer to what are called, in photography, the *revealing phenomena.*

It is generally known that, when the sheet of prepared paper is withdrawn from the *camera obscura,* the action of the light seems to have produced no particular effect on its surface; and yet, when it is immersed in a certain bath, the image immediately appears. This, in the language of the photographers, is the revelation of the image. We shall accept this word, ambitious as it is, and endeavor to render an account of the phenomenon, the most important and certainly the most curious of photochemistry.

What we must first remark is the following observation of M. Niepce de Saint Victor: the function of the two active substances is reciprocal; it is a matter of indifference whether the substance styled sensitive, iodide of silver for example, be exposed to the light and afterwards washed with the revealing substance, pyrogallic acid, or, inverting the process, the gallic acid be impressed and the sheet washed in the bath of silver. As regards intensity, the same effect is always obtained by exposing one or the other to the sun.

M. Niepce de Saint Victor studied this phenomenon with care, and the following are some of the experiments which he made to this effect. He exposed to the sun, for some time, a sheet of white paper which had received no preparation, and he perceived that this paper, placed in the *camera obscura* on a sheet of sensitive paper, blackened it as the light itself would have done. Upon this, he conceived the idea of insolating or exposing to the sun his sheet of paper after having first covered it with a photographic stereotype; he then placed it on a sensitive paper. Not only had the white paper thus insolated acquired the property of reducing the salt of silver of the sensitive paper, but it reproduced on its surface the figure of the stereotype.

This curious property is exerted at a certain distance, but it ceases if a plate of glass or of mica be interposed. The insolated paper retains this property for some time in darkness, but when once this paper has produced a certain effect, the property is completely annulled; a new exposure to the sun is necessary to restore it.

M. Niepce made this discovery under rather singular circumstances. He exposed a sheet of paper to the action of the sun, enclosed it in a tube of tin, and, at the end of some months, having opened the tube, he placed the paper on a sheet which had been rendered sensitive. The latter received the impression in the whole extent of the section of the tube.

How is this phenomenon to be explained? There are two modes of doing it. M. Niepce supposes that there is light imprisoned in the insolated substance. This light sometimes remains stored therein for a considerable time, till the opportunity occurs for it to produce an efficient chemical action. It is scarcely necessary to say that this explanation, simple as it is, has not met with universal acquiescence; difficulty has been felt in comprehending how light could thus remain in a latent state on the surface of bodies for a time which may be termed indefinite.

Another explanation has therefore been advanced: it has been supposed that the solar radiation occasions the formation of highly oxydable chemical products when it takes impression on the organic material. It would be easy then to explain the indefinite preservation of a volatile substance capable of acting at a distance, and disappearing after having produced a determinate chemical effect.

To which of these two explanations should we give the preference? For my own part, I strongly incline to that of M. Niepce, chiefly on account of the following experiment: M. Niepce takes a piece of porcelain presenting a fresh fracture, exposes it to the sun, and then plunges it in the bath of silver, avoiding with care the contact of organic substances; having afterwards washed it with pyrogallic acid, he sees the silver immediately reduced. It is impossible, however, to admit the production of an organic matter under these conditions. The action of the sun, whether on the salts of silver, or on organic matter, or on porcelain, always produces the same effect.

I have said that I incline to the explanation of M. Niepce: I do so, however, with some degree of hesitation; and yet, when I see the phenomenon of phosphorescence, when I see an alkaline sulphur absorb light and give it out, in the end, under the form of light, how can we persist in doubting that a substance like a fracture of porcelain may so far retain light as to cause it to produce, after a time, not phosphorescence, indeed, but a chemical action? It is, in a word, a force which remains there, for quite a long interval, until it finds the occasion for exert-

ing itself in reproducing the phenomenon of photochemistry. However this may be, we continue the study of these phenomena.

If we receive a pure spectrum on paper rendered sensitive, we shall find that the calorific rays do not in general act: the more luminous take no effect; the more refrangible rays, on the contrary, which also produce phosphorescence and fluorescence, are the only ones capable of developing chemical action. For the chloride of silver, the effect commences at the ray F, attains its maximum at H, and becomes progressively weaker up to the limits of the ultra-violet rays. For the chloride of gold the effect is more capricious; the action is slow in being produced, but, once commenced, it continues spontaneously, even in the dark. The iodide of silver begins to alter in the red and presents two maximums. These few examples suffice to show that each substance is impressible by particular rays.

We must not think, however, that the calorific and luminous rays are destitute of all action. If a paper rendered sensitive be covered with glass of various colors, blue, yellow, or violet, for example, we shall find, after an exposure of some moments to the sun, that the red and yellow glasses have produced no action, and that the blue glass alone has acted. If, however, we begin by causing the violet rays to act for a very short time, and the sensitive paper be then placed under red glass, the action is continued. The red glass, which did not possess the property of commencing the chemical action, has therefore the property of continuing it after it has commenced. It is for this reason that M. Ed. Becquerel, who discovered these phenomena, has given to the rays of little refrangibility the name of *continuator rays.*

The resin of guaiacum presents a peculiar phenomenon: it becomes oxydized only under the influence of the violet rays. M. Becquerel, having impregnated a leaf of paper with resin of guaiacum dissolved in alcohol, exposed it to the violet rays, which oxydized it in rendering it blue; having then submitted it to the action of light under a red glass, he found that it became deoxydized. In the case of organic substances, then, there is an inverse action between the luminous rays and the chemical rays which it would be interesting to study, especially with reference to the different phenomena of photochemistry. We have previously seen that, with the metallic salts, the chemical rays were alone *excitators,* but that the luminous rays were *continuators.* This very important distinction between the different rays of the spectrum is again encountered in the daguerreotype. Every one knows how daguerrean proofs are made. The operation consists in exposing to the vapors of iodine a well-polished plate of silver, for the purpose of covering it with a thin layer of the iodide of silver; it is afterwards exposed to the light in the camera obscura. Wherever the light has struck it the iodide of silver is reduced. It suffices next, in order to render the image visible, to expose it to mercurial vapors; the mercury is fixed, wherever the light has struck the plate, in the form of minute globules, giving it a deadened color; it is now only necessary to wash the plate with hyposulphite of soda. M. Claudet has shown, by the following experiment, that, even on daguerrean plates, the luminous rays destroy the effect of the chemical rays. He exposed an iodized plate in the camera obscura, and then cut it into four parts; he observed that the first could condense the vapor of mercury and yield an image; the second he left in the dark, and placed the third under a red glass. At the expiration of some time, the third had lost and the second had retained the property of giving an image with mercury; the fourth, kept also under red glass, recovered its former sensibility, while it had lost all trace of an impression. It would therefore serve anew to produce an image, a fact very important in practice, because it admits of operating in the light.

Thus we see that the violet rays possess the property of deoxydizing the metallic salts and of acting as oxydants on organic substances. The red rays, on the

contrary, in the first case are only continuators, but they become reductors in the presence of organic substances.

MM. Bunsen and Roscoe have sought to estimate the quantity of the chemical forces annually discharged on the globe by the sun; they caused the solar light to penetrate by a very narrow aperture to a vessel containing a mixture of chlorine and hydrogen. These gases, which do not combine in darkness, combined over the whole tract of the luminous ray in proportion to the quantity of the radiations absorbed. In a word, if the aperture by which the light arrives be doubled or tripled, the quantity of chlorhydric acid formed is also doubled or tripled. In this way, MM. Bunsen and Roscoe found that the quantity of chemical rays annually discharged by the sun is capable of combining a stratum 35 metres in depth of mixed hydrogen and chlorine gas. The terrestrial atmosphere absorbs a part of these rays, so as to reduce to 17 metres the stratum of chlorhydric acid which would be formed under the normal inclination, and to 11 metres if the sun traversed the atmosphere at 45 degrees.

It is also to photochemistry that the action exerted by light upon vegetables is to be referred. Bonnet ascertained that leaves immersed in water and exposed to the sun disengage a gas by their under surface. Priestley announced that plants have the property of restoring its primitive purity to the air vitiated by animals. Towards the close of his life, having repeated his experiment, he arrived at a different result, and failed to detect the secret of this difference. It was Ingenhousz who explained this phenomenon in 1779. He proved that under the action of the solar rays the green parts of plants purify the air, while, on the contrary, they vitiate it in darkness. By what rays are these effects produced? If the view which we have taken may be regarded as correct, we are justified in saying that it is the red and the yellow rays which cause the production of oxygen; the others produce carbonic acid. The experiment has been conducted by M. Draper, under conditions which leave nothing to be desired. He took seven tubes of glass containing water charged with carbonic acid, and introduced into each a leaf of grass; he then caused one of the seven colors of the spectrum to fall on each tube. After an interval of time, oxygen was disengaged in the tubes exposed to the yellow and red rays; in the others there was none. The red and yellow rays, therefore, are those alone which give to plants the property of renewing the oxygen of the air.

I shall conclude by stating in a few words the means employed in the practice of photography. A plate of glass is taken, perfectly cleansed, and is covered with a thin coat of collodion containing suitable proportions of bromides and iodides. Before the plate is entirely dry it is plunged into the bath of silver, the operation being conducted under protection from the light; it is then exposed in the camera obscura. To bring out the image it is enough to wash with pyrogallic acid. Lastly, to prevent ulterior alteration it is washed with the hyposulphite of soda. It is thus that a negative proof is obtained; to obtain positive proofs it suffices to apply this on paper rendered sensitive and to expose the whole to the light.

It is not probable that photography will be limited to the progress which it has made up to the present time. At this moment, great hopes are entertained of obtaining, and that at no distant day, not only the outline of objects, but also their proper color. Some time has already elapsed since M. Edmond Becquerel conceived the idea of submitting to the action of the solar spectrum a plate on which he had deposited a thin layer of iodide of silver. After the lapse of a considerable time he thus obtained a perfectly distinct image of the spectrum, with its stripes; and, what is remarkable, even the obscure calorific rays were also represented. But the point most to be remarked in this experiment is that the spectrum was colored. Unfortunately it was impossible to fix these images, and only a very fugitive proof was obtained. M. Niepce de Saint Victor occupied himself with these phenomena, and obtained in the camera obscura photo

graphic portraitures, chiefly of dolls, with their colors. He did not succeed, however, any more than M. Becquerel, in obtaining a persistent image. M. Poiterin has taken up the inquiry, and by means of paper rendered sensitive through chloride of gold and chromic acid, has obtained colored images of quite pleasing appearance, a little more durable, and which may be even preserved in an album. Their preservation, however, is compatible only with a diffused light; but it is probable that ere long success will attend the efforts for perfecting this part of photography.

In concluding, I would wish to give especial prominence to the idea that, if heretofore much attention has been bestowed on photography, there is still something more interesting. It is the chemical action of light; it is this transformation of a certain sort of movements in a phenomenon which, until now, has been considered as a mechanical one, but which enters, through these experiments, into the phenomena of optics.

DORPAT AND POULKOVA.

BY CLEVELAND ABBE, DIRECTOR CINCINNATI OBSERVATORY.

The present condition of practical astronomy in the United States must awaken strong hopes of our future eminence in cultivating this most useful science. But in order to avoid committing grave mistakes and to press due onward in the path of usefulness, we must carefully study and profit by the experience of our predecessors. Germany and England have each impressed certain characteristic features upon astronomical instruments and methods of research: it may be expected that the younger nations, Russia and America, will with cosmopolitan impartiality make such use of the results of the past experience of astronomers as will determine an epoch of still further advancement.

We should do injustice and convey an erroneous impression, however, if we characterized any school of astronomy as especially national—for it is and must be in a considerable degree individual. It is to Kepler and Roemer, to Bradley and Herschel, to Bessel and Airy, that practical astronomy is indebted for much of its present perfection, if, indeed, we ought to make any distinctions among a host of names of those who have contributed their experience and labors towards the increase of human knowledge. Those who have studied the steady march of our science during the past fifty years scarcely need to be reminded of him to whom Dorpat owes its fame and Poulkova its magnificence. To appreciate this latter imperial observatory one must consider the beginning of the history of Struve and his school of astronomy in their humbler home in Dorpat, the Heidelberg of northern Europe: to that beautiful city let us direct our steps.

Leaving the St. Petersburg and Warsaw railroad at Pskoff, whose mouldering battlements have not long been deserted by mailed warriors, sunrise finds us on board of a neat little steamboat that is to bear us down a quiet river and over the famous lake Peipus, away from Russia westward into the ancient country of the conquered Letts. Very interesting are the views of the Lettish fishermen and their villages on our right and left as we in the afternoon ascend the meandering Embach. At length the last rays of the setting sun suddenly disclose before us the dome of the observatory and the ruins of the cathedral, amidst groves whose bright autumn leaves annually strew and will at last obliterate the battle-field and the fortress.

Many are the eventful years preserved in the history of the ancient town of "Derpt." Centuries before the building of its majestic cathedral, the fortressed hill, covered with its primeval forests, was the chosen battle-ground of Swedes, Letts, Finns, and Ests—themselves the successors of the antediluvian races whose only records are now found in the stone implements collected in the museum of the University. The westward progress of the Sclavonic empire caused the village at the foot of the hill to become a city of merchants; whilst with its increasing wealth and strong fortifications it became in peace the thoroughfare of the overland traffic between Europe and China and in war the coveted strategic post. Seven times sacked and burned, it had as often risen anew from beneath its ashes, until finally the civilization of southern Europe and the founding of St. Petersburg robbed Dorpat of its importance. An hundred years ago there remained only ruins and the remembrance of former glory. Here, black and mossy with age, the old stone bridge still spanned the Embach; there, portions of the rebuilt walls, and the quaint church of St. John's, told of

bygone times; whilst always, with impressive silence, the crumbling cathedral looked down from its commanding height, directing one's thoughts through the five past centuries back to the time when its own beauty was renowned through all the land.

Seeking to retain for Dorpat its former military importance, the Empress Catherine ordered her engineers to make of the entire hill, including the cathedral, an impregnable fortress. The work was left only partially finished at the close of the past century, and the immense earthworks still remain. May they ever stand as an emblem that wisdom is stronger than force, and that the reign of war is to be everywhere succeeded by the reign of knowledge.

It was certainly the instinct of true wisdom that in 1802 prompted the Emperor Alexander I to dedicate this hill to the use of his new university. The for-fortifications have been planted with shade trees, in the midst of which are found the ruined cathedral, several of the university buildings, and the pleasure walks of the Dorpat students. On the northeast brow of the hill is the observatory, built upon the massive foundation walls of the former bishops' palatial residence; a few steps from its porch brings one to the brink of bastions fifty and one hundred feet high; whilst from its dome the eye ranges over that beautiful country whose fitness invited Struve to begin the geodetic work that forty years later had stretched northwards to the Arctic sea and southwards to the Danube. As the illustrious Carl Ritter could in the growth of his own mind trace the influence of the wide panoramic view familiar to him in his youth, so may we well believe that the ever present "Dom Ruine" and the beautiful broad landscape have exerted no little influence upon the lives of Struve and the many others who with him hail Dorpat as Alma Mater. Thrice dedicated: to War, to Religion, to Education; may "coming centuries still find the home of learning sheltered beneath those quiet groves."

It is with pleasure that one contemplates the life of a great and good man, whose whole course was a continued success, and who richly merited the unbounded favor of emperors and the lasting respect of all. Such was Friedric Georg Wilhelm Struve; and often as the story of his brilliant career has been told, we will again rehearse its noteworthy features.

Inheriting great ability, he received at the hands of wise and devoted christian parents, at their home in Altona, so thorough a physical and mental development that at his entrance, in 1808, at the age of 15, into the student life of the university at Dorpat, his superiority was already perceived. His elder brother Carl was then a lecturer at the university, and his own attention was strongly turned to philology as affording a very congenial field for future lifelong labor. It was not until after three years spent in literary studies, and after gaining the highest university prizes, that he began to attend the lectures of Huth on mathematics and of Parrot on physics. Huth had in 1809 succeeded Pfaff as professor of mathematics and director of the observatory, and held this chair until his death, in 1815.

Obliged, for self-support, to give instruction as a private tutor, his residence at Sagnitz with his patron, the Count von Berg, was fortunate, in that Struve could find convenient relaxation from his duties in making a slight topographical reconnoissance of the surrounding country. This was in the summer of 1811, a period signalized by the splendor of the great comet of that year. No wonder then, that when in the autumn Struve began his attendance upon the scientific lectures of Huth and Parrot, he, as an enthusiastic student, with his own hands released the long-neglected telescopes from their packing boxes, and perfected himself in their use. His observations of the angle of position of the components of Castor, in August, 1811, show that his attention was now engaged by astronomy as decidedly as it had in the early summer been turned towards geodesy. Through the remainder of Struve's life these correlated subjects equally engrossed his energies and were equally advanced by his labors.

With the reception of his doctor's degree, in October 1813, and the commemorative memoir upon the geographical position of Dorpat, Struve ceased to be ranked among the students, and received in the following month an appointment as professor extraordinary and astronomical observer. This was accomplished through the influence of Professor Parrot, to whom Dorpat and science thus owe many thanks.

The observatory had been built under Pfaff's directorship, and furnished with some instruments; but these might have long remained useless and unknown had not an indefatigable observer been sent in the person of the young student who now succeeded to Paucker as the "observer" under Huth's directorship.

It was not in Struve's power to remove the many defects in the observatory building and instruments; but then, as ever afterward, he showed his ability and disposition to make the best possible use of whatever means were at his disposal, as he himself explains in the introduction to the first volume of the Dorpat Observations:

> When, three years ago, the position of observer in this astronomical observatory was given to me, I considered long and seriously whether I might not, in the then state of the observatory, carry on such a class of observations as that something of use in increasing our knowledge of the starry heavens might possibly be deduced therefrom.

England had long been celebrated for instruments, and the massive walls of Dorpat observatory contained fine specimens of the work of the best English mechanicians. One may still see these preserved there as mementos of bygone days.

The control of the instruments was now left by Huth entirely in Struve's hands, and from the commencement of 1814 dates the scientific activity of the observatory, whose history for twenty-five years continues to be identified with that of Struve; for the succeeding quarter century it has been honored by the presence of the illustrious Maedler; at present Professor Clausen with cordial hospitality presides within its honored walls. It is not our design to trace minutely the history of the observatory and its director, but rather to call attention to the steps by which were realized the hopes and plans of Struve's early youth.

In June, 1812, whilst conducting some experimental trigonometrical surveys in Livonia, Struve foresaw the grandeur of the geodesical operations that might grow from the beginning there made. His first scientific journey in 1814, and his second in 1815, (which was also his wedding tour,) introduced him, as the astronomical observer of Dorpat, to many of the prominent German astronomers, and opened a personal acquaintance that was afterwards of eminent service to him. His succession in 1815 to the vacancy caused by the death of Professor Huth placed him in a position of authority; and the separation in 1822 of the chairs of astronomy and mathematics (this latter being given to Professor Bartels, to whom Professor Minding now succeeds) left Struve full liberty to push forward in his chosen field of activity.

The geodesic work for the map of the province of Livonia, ordered by the Liefland Economic Society, occupied the summers of the years 1816–1819, and brought the geodesist in contact with General Tenner, of the Russian military engineers, who was pursuing a similar work in the neighboring provinces. No sooner was Struve's work finished (in its prosecution a 10-inch sextant and an arc for the measurement of small vertical angles were the principal instruments used) than he laid his definitive plans for the measurement of an arc of 3° 35′ before the council of the university, by whom the undertaking was sanctioned. The necessary appropriation was granted by the Emperor Alexander, who directed that Struve should order the needed instruments in person, from the best makers; and who further showed his appreciation of the astronomer's past labors by a munificent appropriation for the purchase of better instruments for the university observatory.

In the summer of 1820 Struve made his third journey, visiting southern as

well as northern Germany, drawing to him the hearts and good wishes of all, especially his younger co-workers. Having seen the most renowned mechanists and discussed with them the details of his new and long-hoped-for instruments, he returned to the university to await their arrival. The Reichenbach Universal Instrument was received in 1821, and in 1824 he began to use it in the proposed geodesic operations, (in which Baron von Wrangell, of the Russian navy, was his efficient co-laborer.) This latter work was nearly completed in five years. The results are found in the "Beschreibung der Breitengradmessung; Dorpat, 1831." The three-foot meridian circle, the mate of which was found at Königsberg, was received at the observatory in 1822. Observations with it began in October, the winter months being henceforth especially devoted to astronomical labors. It was in this year also that officers of the army and navy began to be sent to Dorpat to study practical astronomy under a man of such ability. In November, 1824, the nine-inch refractor of Frauenhofer was received, and in February was begun the review of the heavens, whose results were published in 1827 in the "Catalogus novus generalis stellarum duplicium et multiplicium." In this latter year it was that Professor Parrot was called from Dorpat to reside at St. Petersburg as a member of the Imperial Academy of Sciences, and almost directly thereafter he was commissioned to prepare for the Academy the plans for the new astronomical observatory, whose erection had long been before the consideration of that body.

The labors imposed on Dorpat during the years 1820–1830 only stirred the unwearied savant to greater undertakings, and as the work on the arc of the meridian drew to a close, Struve, in 1830, presented to the Prince von Lieven, the minister of public instruction, a memoir relative to the possibility of prolonging this arc northwards through Finland. Simultaneously with Struve, General Tenner had been at work to the southward; the junction of Tenner's and Struve's work had been effected in 1828–1829, affording a meridian arc of 8° 2′, which, by the proposed measurement of an arc of 5° 26′ in Finland, could be united to the work of the French astronomers in Lapland, thus completing an arc of 15¼°. The difficulties to be encountered in Finland promised to be unusually great, but the desirability of the work was properly represented, and the Emperor Nicholas I granted at once the sum thought to be sufficient for its completion within ten years.

In the spring of this year, and in connection with the great undertaking just mentioned, Struve made his fourth scientific journey, extending it to England, and in December visited St. Petersburg, where he was, in January, 1831, honored by a personal interview with the Emperor—an interview fraught with the happiest consequences to the progress of astronomy in Russia. This was the moment that had long been looked forward to by the director of the Dorpat observatory, who had doubtless foreseen the inevitable result that would in due time flow from his labors, both as geodesist and astronomer, during the previous fifteen years. Struve's admirable tact and the eloquence of his earnest sincerity were ever equal to the demands of the occasion, and we cannot do better than quote his own account of this interview, at which the minister of public instruction, the Prince von Lieven, was the third person present:

Having listened to my report upon the late scientific journey, and after having graciously granted an increased sum to the observatory of Dorpat, the Emperor condescended to put to me the following questions:

"What is your opinion of the observatory of St. Petersburg?"

I did not hesitate to respond, in all frankness and in accordance with the exact truth, that the observatory of the Academy did not at all correspond to the present demands of science, and that it partook of the nature of all the establishments of its kind placed in the midst of large cities, as those of Vienna, of Berlin, &c., and even of Paris, where the meridian instruments ought to be removed from the colossal edifice constructed under the reign of Louis XIV, and be placed in modest apartments adjacent to the principal structure.

Having listened to this reply, his Majesty addressed the minister of public instruction, saying that he regarded the establishment of an observatory of the first rank near to the capital as an object of high utility and important to the scientific honor of Russia.

The minister did not fail to inform the Emperor that the Academy of Sciences had for some years, occupied itself with the project of a new observatory, and that he had only awaited the completion of the plans and drawings in order to lay them before his Majesty. Then the Emperor ordered that the project should be presented to him as soon as it should have been matured. Finally, his Majesty condescended to direct his attention to the choice of the location for the institution to be erected. The minister having mentioned the site to the north of the city and offered as a gift to the Academy, the Emperor condescended to express himself in the following terms:

"How? The Academy thinks to place the new observatory quite near the city on the north side, and upon a sandy and marshy soil? That is hardly advisable. I would suggest another position. It is upon the heights of Poulkova that the observatory should be placed."

Then his Majesty condescended to address to me the following words:

"Sir Astronomer, you perhaps think it strange that the Emperor should wish to correct the Academy in a scientific matter. But do you know Poulkova, and what do you think of the site?"

My reply was that in 1828, passing for the first time by Poulkova in the company of the Baron von Wrangell, I had been so struck with its position that I had, as if prophetically, exclaimed: "There upon the hill of Poulkova it is that we shall one day behold the observatory of St. Petersburg."

Such is Struve's graphic account of his first interview with the Emperor Nicholas. How rarely does history offer to us a brighter picture than this in which the frank and enthusiastic savant reveals to the willing monarch the path to honorable glory.

The astronomer returned to Dorpat to find that the endowment of his observatory had been largely increased, and that he was in a position to undertake still greater labors.

It was in October, 1833, that the Emperor Nicholas saw fit to give his definite orders concerning a new observatory. The long matured plans of Professor Parrot and the Academy were thereupon presented; these being accepted, their execution, at an estimated expense of 200,000 silver roubles, was ordered. A committee, consisting of Messrs. Wisnieffski, Fuss, Parrot, and Struve, was appointed by the minister of public instruction (Ouvaroff) to study and execute the plans approved of by the Emperor on the recommendation of the Academy. It was as well an impulse of duty towards his science as of gratitude to his benefactor, that led Struve to express to the minister his opinion "that the plan proposed by the Academy and given into the hands of this committee would fail to realize the high anticipations of their august sovereign." The committee were ordered to revise their work; new plans were matured; the details of the mutual relations of the prospective astronomers of the institution were discussed with the Emperor in person; Admiral Greig, the founder of the observatory at Nicolairsk, was made president of the commission, and in March, 1834, the ground was occupied for the erection of the new observatory. In the following month Struve, on behalf of the committee, was presented again to the Emperor, and a second time his personal representations resulted to the advantage of the interests of astronomy. After explaining the motives that had led the committee to prepare plans for a far more costly observatory than had been before contemplated, these latter received the imperial sanction, and Struve was ordered to superintend in person the construction of the necessary instruments.

In the following summer a fifth journey into Germany was made on business, which was specially congenial to Struve. After months of study and discussion on the details of the new instruments, Ertel of Munich and Repsold of Hamburg were intrusted with their construction, and they have since proved themselves well worthy of their places in the Central Observatory. The corner-stone of the building was laid with due formality on the 3d of July, (June 25, O. S.,) 1835, and the entire structure progressed slowly but steadily towards completion. In 1838, on his sixth journey, Struve revisited Hamburg and Munich, examined his new instruments, now nearly completed, and, after making minor improvements, finally approved them as satisfactory. He had four years previously been directed by the Emperor to superintend the construction and equipment of the

observatory; he was now chosen by the Academy of Sciences and confirmed by the Emperor as the first director. In the spring of 1839 he removed his residence from Dorpat to Poulkova, and on the 19th of August the formal inauguration of the activity of the observatory was celebrated, and those under whose guidance so complete a success had been attained received the well-deserved congratulations of the Emperor and the astronomers of his empire.

Whilst we are thus contemplating the rise of Poulkova we should not forget the importance of the past ten years in the history of Dorpat. From 1828 to 1831 Struve and Tenner had been engaged in joining their respective measurements of meridian arcs. The description of this operation was published in 1832; the full account of Struve's work having appeared in 1831 in the "Die Breitengradmessung." The operations in Finland were then taken in hand and pushed on to their completion in 1844, the difficulties of the ground and the distraction incident to the erection of the Poulkova observatory having delayed the work only a very little. In 1837 was published in the "Mensuræ Micrometricæ" the observations on double stars, made with the Frauenhofer refractor, during the thirteen years that had elapsed since its reception in 1824 in Dorpat. In 1839 appeared the fine volume containing the Dorpat observations of Halley's comet in 1835. Add to these the regular meridional observations and their reductions for the years 1825–1841, as found published in the 6th, 7th, 8th and 9th volumes of the Dorpat "Observationes Astronomicæ," and we see that the older observatory was not neglected in the expectation of the new. In the year 1822 had been inaugurated, as before mentioned, the practice of sending a few military and naval officers to Dorpat to study under Struve; his course of lectures was continued with but few interruptions until, by his removal to Poulkova, he was able to make that a school of practical astronomy as well as an observatory.

The history of Dorpat after the inauguration of Poulkova presents several very interesting chapters; the quiet of the shady walks under her linden groves was no longer enlivened by the activity of the many students whom Struve had gathered about him, but if the professors missed their brilliant co-worker, or the social circles missed his numerous family, all were in part reconciled to their loss by the presence of his celebrated successor who was called to Dorpat, after some little delay. In the winter of 1865–'66 Professor Maedler retired from his directorship to find in elaborate historical investigations that rest from his exhausting astronomical labors which failing sight had forced upon him. Six volumes of Dorpat observations published during the quarter century of his administration attest the activity of the observatory, and many investigations into the orbits of double stars, as well as those upon the proper motions of the stars and of our solar system, show his ability as an astronomer. The present director, Professor Clausen, and his assistant, Mr. Schwartz, well known by his contributions to the geography of Siberia, have added to their other labors a series of observations with the Reichenbach meridian circle in accordance with the plan proposed by Argelander, as a means for comparing the peculiarities of the principal instruments and observers of the world.

It has been remarked that after the inauguration of Poulkova it became instead of Dorpat the school of practical astronomy for Russian officers and scientists. Of the former over seventy names are recorded during the first twenty-five years of the existence of the observatory, all of whom have more or less distinguished themselves by their ability and activity. Of Russian and foreign professional astronomers about forty have within the same period availed themselves of the privilege of from one to five years' residence at this magnificent institution, of whom many are already well known in the astronomical world. It was inevitable that the educated geodesists sent out from Poulkova through the length and breadth of the Russian dominions should secure for their scientific alma mater the honor and influence that she so richly merited. Struve was pre-eminently an

utilitarian, and he found in this opening field of usefulness the proper opportunity for fully reimbursing the government for the great expenses attendant upon the maintenance of the observatory. But the diversion of the small astronomical force of the observatory from scientific investigations to practical applications, from study to teaching, in the course of time threatened to seriously interfere with the attainment of the first and important aim of the institution. So long as the extended labors of the Central Observatory were borne by five persons, (the director and four adjunct astronomers,) so long must the general progress of the observatory work be painfully slow, and the urgent need for making provision for further assistance, especially in the matter of reductions, became daily more pressing.

It was in 1856 that the observatory was called upon to lament the death of its founder and friend, Nicholas I, whose name it has since borne, but the imperial successor, the present Alexander II, failed not to provide bountifully for the proper maintenance of an institution so useful to the state and so honorable as a testimonial to the wise munificence of his father. Within a year the annual income of the observatory was doubled, and the friendly dispositions of the department of war, of the navy, and of public instruction, were abundantly manifested by their respective ministers. Not only were the hitherto meagre salaries of the four astronomers now properly increased, but by the addition of two adjunct astronomers and two permanent computers, as well as by the ability to engage temporary assistance, the effective working force of the observatory was nearly doubled, and the immediate danger that abstract science would be entirely supplanted by its practical applications was averted.

The change in the relations of the Central Observatory to the various departments of the civil government which was brought about during the succeeding five years was the inevitable consequence of its active usefulness during the first eighteen years of its history. We will briefly consider the work done at Poulkova during this period, though we can scarcely do more than enumerate the titles of the most important of the one hundred and fifteen memoirs published by its astronomers previous to 1858.

The long series of Dorpat meridian observations extending from 1822 to 1843, already published in successive volumes and in separate treatises, required, in Struve's opinion, a final revision as regards their reductions, and a publication as one work, inasmuch as they had been conducted upon one plan and formed consecutive portions of a symmetrical whole. The original Dorpat records of observation are still preserved at Poulkova in accordance with the laws regarding that observatory, and from them were compiled the resulting catalogue: Stellarum fixarum positiones mediæ; auctore F. G. W. Struve, Petropoli, 1852. The following works must be considered as preliminary to this invaluable catalogue: The Deduction of the Constant of Precession, (St. Petersburg, 1842,) by Otto Struve; the Deduction of the Constants of Nutation and Aberration, by Schidloffski, (Dorpat, 1841,) by Lundahl, (Helsingfors, 1842,) and by Peters, (St. Petersburg, 1842.) In conjunction with the last named memoir is to be placed the determination by Struve (St. Petersburg, 1843,) of the constant of aberration from his own observations made in 1839–1842 with the Poulkova Repsold Prime Vertical Transit. This last was the first important publication of observations made at Poulkova, and was shortly followed (1844) by Peters's Observations with the Ertel Vertical Circle upon the Pole Star; in both of which works the scientific world found the proof of the superiority and accuracy of these new instruments. The first publication of observations with the Meridian Transit is found in Lindhagen's memoir (St. Petersburg, 1849) upon the constant of aberration deduced from observations made on the Pole Star.

These works of universal interest and importance, inasmuch as they have established the authority of the so-called "Poulkova Constants," now in general use among astronomers, were accompanied by others of similar value; such were

the Revision of the northern heavens for all stars to the eighth magnitude, by Otto Struve, in 1841–'42, and the resulting catalogue of 514 new multiple stars, (St. Petersburg, 1843;) the publication of Weisse's Reduction of Bessel's Zones, (St. Petersburg, 1846;) of Döllen's Reduction of the Königsberg Declinations, (St. Petersburg, 1849;) of Otto Struve's Revised Catalogue of Double Stars discovered at Poulkova, (St. Petersburg, 1850;) of Fedorenko's Reduction of Lalande's Circumpolar Stars, (St. Petersburg, 1854.)

And to these we must add certain studies which are of great interest and value from their bearing upon subjects of investigation that still elude our secure grasp: Struve's Etudes d'Astronomie Stellaire, (St. Petersburg, 1848;) Peters's Recherches sur la Parallaxe des etoiles fixes, (St. Petersburg, 1848;) Otto Struve's Investigations into the Parallaxes of 1830, Groombridge, (1850;) of α Lyræ, (1852;) of α Lyræ and 61 α Cygni, (1854;) Döllen's Criticism, St.) Petersburg, 1853;) of Wichman's Parallax of 1830, Groombridge.

Nor had the attention of the observatory been drawn from the bodies of the solar system. In 1843 was published the elaborate memoir on the orbit of the comet of 1839–'40 by Peters and Otto Struve; in 1849 and 1850 the Observations of the Satellite of Neptune and Deduction of Neptune's Mass, by Otto and August Struve; in 1852 Otto Struve's Observations of the Rings of Saturn, and in 1854 his Observations of Biela's Comet; finally, in 1853, by Struve and Liapounoff, the Reduction of the Dorpat Observations of the Sun, Moon and Planets.

In practical astronomy the publication (1845) of the Description of the Central Observatory had formed a memorable epoch, and the annual Russian edition of the English Nautical Almanac brought that indispensable work to the convenient use of the Russian officers.

In geodesy the expedition of 1838–'41, suggested and planned by Struve for the determination of the difference of level between the Black and Caspian Seas, (St. Petersburg, 1849,) had added much to the geography of that little known portion of what was then the Russian frontier, and gave occasion to Struve to make a very valuable contribution to our knowledge of terrestrial refraction; the longitude expeditions to Altona and Greenwich in 1843–'44, and the annual geographic expeditions into the interior of Russia, and especially the steadily progressing measurement of a grand meridional arc of 25 degrees of latitude, were continual reminders of the vastness and national importance of the works undertaken by the Central Observatory, and by those who were the co-workers of its amiable director.

Nor was the rapid progress of astronomy in Russia unnoticed by the astronomers of foreign countries. Already in 1840 had the kindly Schumacher celebrated the 25th year of their friendship by a personal visit to Struve, and had borne testimony to the advance that had been realized by the establishment of so imperial an institution; and in 1842 the King of Prussia, on beholding the splendor of Poulkova, had the condescension to promise that Bessel and Argelander should certainly have opportunities given them to visit this "Eldorado." It was, however, not until 1853 that the latter was able to leave Bonn and gratify his long-repressed desire, and the life-long friend of Struve could but say that the half had not been told him. Even from America came tributes to the fame of Poulkova; first, when in 1848 it was visited by our eminent countryman, whose impressions as published in the North American Review (1849) created among us a wide-spread interest in Struve and his Central Observatory; and again when visited in 1851 by the late director of the Harvard College Observatory, to whom, when still at a distance from St. Petersburg, Struve sent a message of welcome.

It was in 1857, when the high rank of Poulkova in matters pertaining to astronomy and geodesy had thus been so forcibly demonstrated at home, and so widely acknowledged abroad, that the necessity became imperative for a change

in the relations of the observatory to the state. In effecting such a change, one long previously foreseen by Struve, many dangers were imminent, many obstacles were to be overcome. But if the director at any moment needed counsellors, his wide acquaintance with and profound knowledge of men secured to him such as were desirable, and among them was one whose position as astronomer royal of England and whose eminent usefulness gave weight to every suggestion.

In 1844 the advanced condition of the work on the Finland prolongation of the arc of the meridian had demanded that the next step, namely, the preliminaries to its extension to the North Cape and to the Danube, should be definitely agreed upon. Struve had, therefore, been sent to Stockholm, where an interview with the Swedish commissioners and a final interview with the King of Sweden led to a most satisfactory adjustment of the relations to be borne by the various parties in the concluding portion of this extended international work. On account of the quarantine regulations Struve found it convenient to visit Germany and England in the course of this journey. This visit, in connection with the longitude expedition of the same year, had opened a most valuable intercourse with the observatory at Greenwich, and the personal friendship between Struve and Airy was cemented in 1847, not only during Struve's third visit to England, (on the occasion of the transportation of one of the bars of the Indian base apparatus,) but still more by Airy's consequent visit to Poulkova and his kindly criticism of the peculiar features of that observatory. Widely as the latter institution differed from its English predecessor, they yet had many common interests. Central in its location, honorable in the history of its usefulness, and peculiarly favored by the state patronage, the position of the Royal Observatory of England was very similar to that which Poulkova now virtually occupied, and it became Struve's desire to secure more completely for the latter that stability and unembarrassed independence that had long been enjoyed by Greenwich. Not only prudential considerations, but also the interests of the many other observatories in the empire, were a matter of anxiety; possibly a certain clause in the original laws regarding the Central Observatory, or possibly the name itself, may sometimes have led similar institutions in Russia to fear lest Poulkova, overstepping proper bounds, might assume authority over them; but the astronomers of the imperial establishment had ever labored to dispel any such injurious illusion. The appointment of Struve by the Imperial Academy, in 1857, to prepare a new set of laws for the reorganization of the internal and external relations of the observatory was the opportunity by which he sought to remove all misapprehension and to realize increased usefulness. Five years, however, must elapse before the new code of laws could officially go into operation; a delay which, while it may have resulted in perfecting the new statutes, was itself the consequence of most painful events.

His exhausting labors in connection with the invaluable new catalogue of the Poulkova library, and the publication of the "Arc du Meridian entre le Danube et la mer Glaciale, St. Petersbourg, 1860–'61," had necessitated a little recreation, which Struve found in a short trip in October and November, 1857, to Germany, France, Switzerland, and England. This was Struve's eleventh absence from Russia, and afforded him the opportunity of urging the importance of, and of preparing the way for, an international measurement of an arc of longitude, in which work he had ten years previously enlisted the active co-operation of General Wrontschenko, then conducting the Russian geodetic surveys. In January, soon after his return to Poulkova, a severe attack of cancer prostrated his strength and necessitated a prolonged absence in the warmer climates of southern Europe. The vice-director, Otto Struve, officiated in his father's place until the return of the latter in August, 1859, and in January, 1862, Otto Struve succeeded as director of the observatory upon the resignation of the former, since there no longer appeared reasonable hope of his recovery. It was thus reserved to the present director, finally, to harmoniously adjust all

the relations of the observatory, and to realize the ideal clearly conceived by the father fifty years previously. It was proper that the son should complete the immortal work of the father, but it is satisfactory to know that before the death of the latter he had already in 1864, on the occasion of the celebration of the twenty-fifth anniversary of the inauguration of the observatory, received the congratulations of assembled astronomers, statesmen, and friends, upon the successful completion of his life-labor, and the auspicious entrance of the observatory upon its new career.

The period from 1857 to August 26–14, 1862, marked as it was by the illness of Struve and the succession of his son, may be considered as a period of transition which was terminated on the latter date by the imperial approval of the new "Statutes of the Nicholas Central Observatory."

These statutes recognize the observatory as having become a scientific astronomical institution of permanent practical importance to the interests of the state; and, therefore, the Academy of Sciences, to which body it had hitherto been directly subject, is now, to a great extent, released from the responsibility of its maintenance and activity. In order to avoid the danger lest the extraneous geographic and geodetic operations should interfere with the progress of scientific investigation, the working force was further increased by placing at the disposal of the director four positions additional to those created in 1857, thus increasing the scientific corps to thirteen persons, and a regulation requiring from each paid astronomer, except the director, three hours daily of computation on the reduction of current work assures us that the long desired Poulkova observations will hereafter be rapidly reduced and published.

The necessity for promptness in business matters was of itself sufficient to demand the newly introduced and direct responsibility of the director of the observatory to the minister of public instruction, thus avoiding the frequent delays incident to the previous relations with the Academy of Sciences. But this most radical and beneficial change was accompanied by the equally wise interposition of a "committee," reminding one of the "board of visitors" of Greenwich, which should annually report to the minister the condition of the observatory affairs, and whose recommendation or approving vote, by reason of the high authority of the individuals composing this body, "would, at any time, authorize the observatory to expect governmental support in its undertaking." The fifth article of the new laws defining the membership of this committee reads in part as follows:

> Section 5. The committee will be composed of persons who belong to those departments on which the labors of the observatory have a direct bearing. It consists of the president of the Academy of Sciences, as chairman; the president of the Imperial Geographical Society; the director of the Military Topographical Bureau; the chief of the Nicholas Academy of the General Staff; the president of the honorable Naval Board; the director of the Hydrographical Department; the permanent secretary of the Academy of Sciences; and of four persons who will be annually chosen by the Academy from among their active or honorary or corresponding members, &c.

On the occasion of the May visitation of this committee to Poulkova it receives the annual report of the director. It is by the organization and active co-operation of this committee, which is indeed nearly equivalent to a "board of commissioners," that the Central Observatory may expect to steadily advance in prosperity. In it are represented not only the scientific Academy, but those departments of the government which, having an interest in the observatory, have also a common duty toward it.

As to the scientific members of the observatory corps, we must notice that the election of the director by the Academy of Sciences and his confirmation by special imperial assent, the nomination of the four senior astronomers by the director and their confirmation by the Academy, the nomination of the adjuncts by the director and their confirmation by the minister of public instruction, all combine to give high political authority, to secure acknowledged scien-

tific ability, and to insure permanent stability—from all of which there will follow the most energetic and best directed activity. These precautions, taken to secure the best use of the money appropriated to scientific research, strike one with the more admiration as existing under a government so autocratic as the Russian. They are due not only to the wisdom of the Emperor Alexander II, and especially to his brother the Grand Duke Constantine, but also to the diversity of the many interests that had clustered about an astronomical observatory, and to the sagacity of Struve and his illustrious successor.

But if we return to the external scientific relations between Poulkova and the other observatories of Russia, we are still more deeply convinced of Struve's consummate ability, in that he was able to dispel the fears which might have led many to suspect that he aimed at a legalized astronomical autocracy. Perhaps the name, CENTRAL, was unfortunately chosen; certainly it might please a military monarch better than the quiet student. But the experiences of others stood the astronomer in good stead, and, notwithstanding the well-meant suggestions of political friends, he endeavored to realize that which would, in its moral beauty, eclipse the material splendor of Poulkova. "This observatory *will* always be a central scientific authority, SO LONG AS IT DESERVES TO BE SUCH," was the sentiment on which Struve rightly desired the prosperity of Poulkova to be based. The interpretation given by the Poulkova astronomers to the obnoxious clauses in its former code of laws is found in the following quotation:

> It is allowed to the Central Observatory to apply the greater means over which she has control to the assistance of the other observatories and the furtherance of the labors that they undertake; and as the central institution it must strive for the most successful co-operation of the different observatories of the empire. To this latter end, however, it possesses no other means than fraternal intercourse. The use of and even the existence of such intercourse must remain entirely dependent upon the estimation in which such is held by the individual directors of other observatories."

This was "co-operation—not monopoly." As to the realization of these principles, we may now behold an empire dotted with many scientific astronomical institutions, harmoniously co-working under the stimulating influence of EXAMPLE. The progress of each is the good of all.

As we perceive the external, wide-spread, national influence of Poulkova to be pre-eminently beneficial, we are thus prepared for the harmony that exists within. Honor to those whose entire devotion to the solitary studies of the astronomer has enabled them, during many years, to labor amicably together, absorbed in the search for truth rather than fame, and imbued with the spirit of the example of their revered senior.

On the 23d–11th November 1864, Struve quietly passed away. His funeral discourse was appropriately based upon the text, "God is love; and he that dwelleth in love dwelleth in God, and He in him." Only such a charitable spirit as he possessed could ever be admitted within the little social circle that constitutes the isolated scientific society of the observatory of Poulkova.

We have followed the history of the Nicholas Central Observatory from its first conception in the mind of Struve to the complete development of the clearly defined ideal through the munificence of the Emperor Nicholas I and the liberal patronage of his worthy successor, Alexander II. The call of Struve to the observatory of Dorpat in 1813, the inauguration of the observatory at Poulkova in 1839, the permanent organization of 1862, and the subsequent quarter-century anniversary celebration in 1864, embrace a space of fifty years. In the history of the past five years, as recorded in the annual reports of the director, we shall find ample testimony to the vigor of the maturity of the observatory. If, turning from the contemplation of its past history, one studies Poulkova as it is, there is found on every side that which pleases both the man and the astronomer. An honor to the Russian empire, it may well serve as a study and example to other nations and to other men.

We shall supplement our rude historical sketch by a few words upon its inner organization and present scientific activity, but would recommend to all the interesting work of Sir Charles Piazzi Smyth, prompted by the hospitality extended to him during his visit to Russia in 1859.

Among the marshes at the head of the Gulf of Finland, and on the islands in the mouth of the river Neva, under the 60th° of north latitude, Peter the Great founded the city of St. Petersburg. A plain surrounds the city on all sides, but at various distances to the east and south this is bounded by ridges that were once the shores of the gulf, when its waters covered the site of the northern capital; beyond these the elevated table lands of the rolling steppes begin. Directly south of the city the plain is limited by a moderate elevation, "the mountain Poulkova," a hill laid out by Catherine for a pleasure garden, but chosen long before her time by Peter as a favorite resort whilst fighting the Swedes and building up St. Petersburg. The great military road southward from St. Petersburg to Warsaw, bending as its course strikes the steep northern face of the ridge, sends a branch off to the southeastward to Tsarskoe-Selo, but itself half encircling the hill Poulkova, continues onward until lost to the sight behind other ridges far to the southward. A village of peasants, formerly imperial serfs, sheltered from the violent westerly gales, has clustered along the roadside, and has given its name to the hill. On the northeast outskirts of the village, and not a mile distant from the observatory, the centre of attraction, we find a favorite spot, whence we behold at once the full beauty of the observatory hill. Looking to the southwest, we see at first only the log-houses and fruit gardens of the villagers, whilst beyond a wild forest covers the mountain. But a more careful scrutiny converts the forest into a semi-artificial grove, "the little Switzerland" of the Poulkovites covering the abrupt northern slope of the declivity. The curving and ascending Warsaw road bounds our diminutive forest on the side nearer to us; on the roadside nestling amidst the green trees of the observatory park is a white-arched porch, covering a far-famed spring. A little further up, and to the left is the dwelling of the former observatory mechanician, whilst very far behind it one sees a tall geodetic signal. Behind the grove peeps out the tasteful little observatory of the officers of the military academy; then the green lawn spreads out in front of the imperial establishment, whose three turretted domes crown the hill.

Those three domes even from a great distance are noticeable features in the landscape. Let us leave St. Petersburg by the broad "Tsarskoe-Selo avenue," and long before entering upon the Warsaw road, even before passing under the triumphal arch, if we look directly south we may see between its pillars the long straight road, the Poulkova hill and the domes ten miles distant. The middle and largest dome appears connected with the macadamized road by a narrow line, but our swift troika soon brings us near enough to perceive that the line is a footpath leading straight up the hill dividing the green forest of our little Switzerland into equal portions on the right hand and on the left. Only the monotony of the surrounding plains can justify our comparison with Alpine scenery, as we readily acknowledge when having ascended to the topmost step of the footpath, we learn that the village behind is scarcely 100 feet below us. Behind us is the long road, with its double row of lindens, and St. Petersburg in the distance; before us is a grassy lawn of ten acres, and beyond that the observatory. Our path leads without turning straight through an avenue of lindens, and between fragrant flower beds up to the doric columns of the vestibule. A shaded path to the left takes us behind ancient elms to the observatory of the military academy; one to the right brings us through a charming grove of evergreens to the "Peter's stone" and the tall signal. The Russian architects well understand the use of colors in relieving the monotony of a wintry snow-covered landscape; we have before us on either hand the deep red-brick dwellings, flanked by evergreens and birches, and enclosing the observatory,

whose brown woodwork and cream-colored stucco resting upon light sandstone foundations, contrast as beautifully with January's snows as with the fresh green of June. One should visit the Peter's stone and the quiet grave-yard, and linger in this beautiful park before entering the observatory. Under the noble elms the village peasants spend many a summer holiday; here travellers stop to rest and lunch, and enjoy the view, and of a pleasant afternoon the observatory families may be seen dining and chatting over coffee or tea—all enjoying the luxury of that open air life that Europeans, and especially the Germans, indulge in so heartily.

Struve's appreciation of the beautiful is seen not only at every step of our walk through the grounds and in the exterior of the buildings, but as pleasantly impresses one on entering within. Whether we consider the director's cosy study or the elegant proportions of the airy observing rooms; whether we visit the magnificent library or the unique portrait gallery of the central rotunda; or study the details of the instruments, or the methods of using them, everywhere is appropriate symmetry, harmony and beauty. But leaving for the present the material structure, every detail of which is so minutely recorded in Struve's "Description de l'Observatoire," let us first consider that which is of prime importance to the interests of science.

The inner organization of any institution should depend not only upon the nature of the material, but equally upon the conditions and nature of the work to be performed. The variety of the demands made upon the Royal Observatory at Greenwich, and the imperative call for daily and annual results, as well as the singleness of the object kept in view, have necessitated a simplified daily routine, and a regulated organization of all the working forces; so that the director holds in his hand a control over the minutest detail of operations; only thus could all demands be met with unfailing regularity. At Paris, but only to a slight extent at Washington, a similar course has been imposed. The value of the regular annual publication of reduced observations is seen, not only in the usefulness of these larger observatories, but also in that of smaller ones, such as those at Berlin, Königsberg, Brussels, Dorpat, Oxford, Edinburg, Madras, &c., and the arrangement by which Poulkova could have published annual volumes of results, would perhaps have been effected by Struve, had not his small force and the diversion of their labors into various channels hindered the execution of this portion of the duties of the institution, until it became apparent that the observations could only be properly published when the distinct work to which they belonged should be completed, and when the diverse parts of each could be framed into an individual consistent whole.

Thus there came to be impressed more and more deeply upon the observatory a prominent trait in Struve's own character, who working always with energies concentrated upon the matter in hand, preferred, if possible, to bring each special work to a speedy conclusion, that it might be given to the world, arranged as a systematic treatise or investigation. "A definite aim being presented, its attainment should mark the proper time for publication." This principle is not entirely inconsistent with the custom of annually publishing the various successive portions of the work in hand; indeed, even the publication of unreduced observations is valuable, both as making them accessible, and as an evidence of life and activity. But loving, as Struve did, general and comprehensive views, and believing that the advance of astronomy was marked by investigations and memoirs, and not by observations alone, being measured by generations of men, and not by single years, this publication of annual fragments seemed only a deceitful appearance of progress and advancing knowledge; the preliminary results to be expected from his new instruments, even if desired as being in their crudeness better than the most of those accessible to astronomers, ought to be withheld until, after severe investigation, they could be presented to the world as the best results the instruments could yield. This train of thought and the

similar course pursued in the early history of many observatories, (of which Greenwich was itself a notable example,) decided Struve to seek usefulness to a future generation, rather than to the immediate present, and not to organize a mechanical observatory, deficient in intelligence, and progressing only with the progress of the science, but rather to develop a "living institution," an association of astronomers, desirous like himself by their own labors to lead on in promoting the progress of their science.

The wide field in which these Poulkova astronomers should pursue their independent yet correlated investigations is indicated in the following article of the statutes of 1862:

§. 2. The establishment of the Nicholas Central Observatory has for its object:

a. The uninterrupted prosecution of observations and works for the promotion of astronomy as a science.

b. The improvement of practical astronomy in its application to geography and navigation, the execution of observations in the interest of the astronomical and geographical labors systematically undertaken by the different departments of the empire, the connection of these labors with each other, and their scientific assistance.

c. To assist other Russian observatories in the attainment of a more successful prosecution of astronomy.

d. To offer to the officers of the general staff of the topographical corps and of the navy, as also to other young scientists the opportunity of perfecting themselves in practical astronomy, and its application to geography and geodesy.

To the attainment of these objects this institution freely opens to those young astronomers who have resided at Poulkova as guest-students, as well as to those who are its permanent officers, the use of the rich material of instruments, observations, and books in its possession. As to the relations with other similar establishments in Russia, their annual reports show how frequently in the details of their equipment and work they are arranged in accordance with the suggestions emanating from the Central Observatory. In matters pertaining to the applications of astronomy to geography there is an especial activity not only in that five or ten officers of the general staff here pursue their two years' practical course under the directions of Mr. Döllen, but also in that the plans for geographical expeditions and the working up of the results are generally more or less confided to him. As to the astronomical investigations carried on at the observatory proper, although all are engaged therein, yet these are especially expected from the senior and adjunct astronomers, who form, as was Struve's desire, an association whose members labor individually for the promotion of their science. The choice of the senior astronomers takes place according to the following article of the statutes:

§ 19. The senior astronomers of the observatory must be chosen from among men of acknowledged ability in the department of astronomy. Unto them by preference will be intrusted by the director the execution of all the works to be undertaken for the attainment of the objects of the observatory, mentioned in §2. The choice of a candidate for the occupancy of a vacancy in one of these positions is the duty of the director. He proposes the chosen candidate to the Academy of Science, which body, when it by ballot has approved the choice, on its part presents the same to the minister of public instruction for confirmation.

It follows from the precautionary process thus enjoined that the four senior astronomers (one of whom is also the vice-director) are but inconsiderably inferior to the director in experience in their profession, and form a permanent council, whose valuable suggestions always have weight in the conduct of scientific affairs.

Besides the preceding permanent members of the astronomical corps, the third article allows two adjunct astronomers and two permanent computers. Thus far the observatory has been, and probably it always will be, successful in securing for these positions young men of promising ability. Indeed, although no system of promotion is officially recognised, yet it will generally happen that the director will be able to fill these positions from among the numerous young men who have resided at the observatory, and similarly to find among the adjunct astronomers those well qualified to become seniors; this is evidently peculiarly desirable in

an institution that differs in many details from others now existing, and contributes not a little to the consistency of the steady progress that experience secures. On the other hand, the fact is never lost sight of that very often profitable suggestions and the infusion of new life are to be expected from the introduction of an entire stranger into the observatory corps; thus the whole institution preserves its cosmopolitan character and is kept from becoming antiquated.

To the nine members of the permanent scientific corps are to be added the younger persons, not military officers, who seek a residence at Poulkova, as allowed by §§ 27, 28, 29, 30, for their own advantage; generally these inevitably contribute something to the furtherance of the scientific work of the observatory, whilst receiving from it the treatment of guests. The new statutes allow the director to give these young men a position and rank as civilians serving the observatory, but not in the service of the state; thus they may be properly considered as supernumerary astronomers, who, however, enjoy some of the privileges of such as are permanently in the state service, which is no mean advantage in the autocratic Russian empire. Although these are at liberty to devote their whole time to their own studies, they yet generally choose to contribute several hours daily to the regular work of the observatory, receiving a small compensation therefor. As there are often four such supernumerary astronomers, we may consider the effective scientific force to number thirteen persons.

The young officers of the military and naval schools who receive their instruction from Mr. Döllen, as they do not dwell on the observatory grounds and only rarely take part in its geographical work until after their graduation, are not to be considered as attached to the observatory.

To the preceding general outline of the officers of the institution let us add the names of those who were, in 1866, attached to the observatory:

His Excellency Otto Struve, director; A. Wagner, senior astronomer and vice-director; W. Döllen, senior astronomer; H. Gyldén, senior astronomer; P. Smyssloff, adjunct astronomer; A. Kortazzi, adjunct astronomer; C. Linnsser, computer; H. Fritsche, computer; Messrs. V. Fuss, A. Gromadski, G. Berg, and C. Abbe, supernumerary astronomers.

At present, however, several changes are noticed since Colonel Smyssloff has accepted the directorship of the Wilna observatory, and Mr. Berg is his assistant. Mr. Fuss has been made adjunct astronomer. Mr. Fritsche has become the director of the magnetic observatory at Pekin, Mr. Knorre, of Berlin, fills his place.

To the preceding officers should be added the secretary, the mechanician, the intendent, and the physician; all of whom, with their families and the soldiers assigned to duty at the observatory, constitute a colony of an hundred and twenty souls or more.

The members of the scientific corps have been spoken of as the colleagues of the director, and the genial spirit infused by Struve will always retain to them that pleasant relationship; but a great power must needs be vested in the hands of the superior, not only in order to perserve harmony of action, but also because of the responsibilities imposed on the director. The tenth article of the statutes defines the duties of the director as follows:

SEC. 10. The principal aim of the director is to direct all the forces and means of the observatory to the successful accomplishments of the objects of this institution, detailed in section two. He must, therefore, see that astronomical observations of the highest perfection be conducted uninterruptedly, and that the instruments used to this end always correspond to the actual demands of science. As immediate chief of the observatory and of the persons stationed there, he conducts the works that are to be executed, allots them, and himself takes part in them.

As it was thus the pleasure of the elder Struve, so is it still the privilege of his successor, to realize that "the activity of the entire institution concentrates in him;" whilst as its head he skilfully controls the moulding of the independent works of his colleagues into one united effort for the advancement of their science.

The activity of the Central Observatory has doubtless suffered somewhat from the restricted communication between Poulkova and the neighboring cities, St. Petersburg and Tsarskoe-Selo. For, however much this isolation favors the undisturbed prosecution of observations and study, it imposes a dreaded monotony upon the lives of the non-astronomical portion of the community, from the effects of which the astronomers themselves cannot be entirely free. To counteract the influence of this sameness—so prejudicial to mental and physical health, and so detrimental to the harmony of society—requires the constant attention of each individual living at the observatory. It will thus be easily understood that the personal example and the influence of the director as a man, no less than his experience as an astronomer, are needed in order to secure the happiest working of all the parts. Possibly the sameness of the social circle exaggerates the influence of the monotony of the astronomical work, for there is in Poulkova no rotation of duties, such as in some other observatories affords a slight relief to the members of the corps.

It was in accordance with Struve's foresight that the efforts of the observatory to realize its general object, "the advancement of astronomy as a science," should be principally confined to stellar astronomy, and that to each astronomer should be assigned the instruments needed for the work undertaken by him, and for whose execution he is responsible, thus reversing a very common practice of assigning the observer to an instrument. The description of the instruments and the mode of using them may be found fully given in the well known "Description de l'observatoire." The following condensed notice of the progress of the works there indicated as having been begun will perhaps have interest.

The *Great Refractor*, made by Frauenhofer, in the central dome, has, since its erection, been used principally by the present director. The general survey in 1841 of the northern heavens, requiring the examination of 17,000 stars, and leading to the discovery of nearly 500 new double stars, has been already mentioned. Up to the present time micrometric observations of relative positions have been made upon 1,200 double stars, which will probably be published in 1869 in all their details. Struve's method of observing position angles, *i. e.*, by placing the two parallel threads of his micrometer so that the space included between them is bisected by a line joining the two stars, leads probably to the interesting systematic errors in observed angles of position, investigated by him in 1852–'56, and again in 1866, by observations upon artificial double stars. In the latter year an investigation was also made of the errors of estimated small distances, and a simple systematic correction deduced, by which these become as valuable as actual measurements with the micrometer. Nine optically double stars have been made the subjects of special investigations for relative parallax. The determinations of relative positions of comets and faint comparison stars have next claimed attention. The series upon the Biela's, Faye's, and Donati's comets, and those of 1861 and 1865–'66, are to be specially mentioned, as also the fruitless search after Biela's comet at its late predicted return. The observations of Neptune's satellite and the determination of the planets' mass have been already mentioned; a large number of observations upon the satellites of Uranus and Neptune still await publication. The occultations of the Pleiades, in which a dozen observers sometimes combine, have been regularly continued. The study of Saturn's rings and of the great nebula in Orion have also claimed attention whenever circumstances have conspired to favor the prosecution of these very delicate observations. The results already attained, and their comparison with those of the Bonds at Cambridge, are already well known to the world. The instrumental changes made in the great refractor have been quite insignificant; but on account of increasing unsteadiness in the parallactic movement the director has proposed to replace the clock-work by some one of the improved mechanisms now made. This will become the more necessary in

order to prosecute telescopic spectrum investigations, the apparatus for which was received in 1866 from Donati.

The *Heliometer*, made by Merz and Mähler, in the eastern dome, for want of an observer could not be brought into continuous use until quite recently. Not only was this delay caused by the necessity of making several much-needed instrumental changes tending to convenience of use and accuracy of results, but it was also best to await the result of the further experience of Bessel, Wichman and Johnson, before deciding to trust so complicated an instrument in delicate investigations. Possibly Dr. Auwer's study in 1861–'62 of the heliometer used by Bessel confirmed the decision to use the Poulkova instrument for other purposes than that for which it was originally intended; and certainly the reported valuable results recently obtained by Rutherford in stellar photography assure us that probably this method will advantageously replace the heliometric for the measurement of large relative distances. From 1858 to 1864 this telescope has been used by Dr. Winnecke in photometrical measurements and in observations upon the several comets, as also upon the conjunction of Venus and Jupiter in 1859. Since 1864 Mr. Fritsche has made use of it in the observations of several asteroids.

The *Small Refractor*, made by Baader, in the western dome, has been principally used in the observation of comets, asteroids, and occultations.

The *Prime Vertical Transit*, made by Repsold, in the south wing, was used until the end of 1842 by Struve himself on the series for the determination of the constant of aberration. Seven stars were observed upon at the periods of maximum and minimum influence of aberration and parallax, and the results are published in his well-known memoir. Observations on three of these stars were continued for the determination of the constant of nutation; the series being interrupted in 1856 by Struve's illness, was continued by Otto Struve, and will probably be soon published. In 1861–'63 this instrument was used by Lieutenant Oom, (now director of the Royal Observatory at Lisbon,) in determining the zenith distances of about 80 stars whose declinations are between 57° 46′ and 59° 46′, each star being observed at least four times. After the determination of aberration and nutation, the proper use of this instrument is found in the investigation of absolute annual parallax; accordingly, in 1866 it was used in the determination of the relative declinations of certain double stars as preparatory to an extended series in which the subjects of relative and absolute parallax, aberration and periodicity of latitude should be simultaneously investigated.

To the *Meridian Circle*, made by Repsold, in the east room, was assigned the observations for a catalogue of 3,755 stars, including all of the sixth magnitude north of 15° of south declination. This work was begun in 1841 by Sabler, and continued by him until 1854, assisted in the interval—1844 and 1849—by Döllen. In the years 1853–'56 Sabler and Lindhagen were occupied in observations of the comparison stars of Biela's comet. The catalogue work was continued by Winnecke from 1858 until 1864; in 1866 its further continuation was assigned to Mr. Gromadski, whose diligence in filling up the many gaps caused by the unfavorable weather of the winter months and the twilight of the summer, authorize the belief that the completion of the series is soon to be looked for. The number of stars that will have been observed with the meridian circle will be greater by 1,500 than that of the catalogue originally contemplated; the reduction of this series of observations has been delayed more than that of any other undertaken by the observatory. It is intended that each star shall be observed in the two positions of the circles and of the interchangeable ocular and objective. The published results of Sabler's and Lindhagen's observations, as given in Gould's Astronomical Journal, and those of Winnecke made at the opposition of Mars in 1862, give assurance of the high value that the catalogue will have when published. With this instrument will be made the determinations of the positions of the 500 stars to be used as fundamentals in the

new review of the heavens lately undertaken by the German Astronomical Association.

The spirit of investigation inculcated by Struve asks for the simplest instruments and the smallest ones consistent with optical power, and demands the most laborious watchfulness over the instrumental errors, together with such a symmetrical arrangement of the observations as to necessitate only the simplest possible assumptions with regard to the unknown or suspected sources of error. These principles have possibly increased the labor and somewhat retarded the completion of the work assigned to the meridian circle, but have had a still more decided influence upon the progress of the work undertaken with the two principal meridian instruments. These stand in the west room, and some of the results attained by them are already known through the memoirs of Lindhagen and Peters.

The *Vertical Circle*, made by Ertel, standing on the west side of the observing room, was used by Peters until 1849, in observations for latitude and the declinations of about 350 bright stars. The determination of latitude has been already published in a memoir previously cited, as also has been the special series in which the absolute parallaxes of the stars Polaris, α Aurigæ, ε Ursæ Majoris, Groombridge, 1830, α Bootis, α Lyræ, α Cygni, 61 Cygni, were investigated. Dr. Gyldén's refraction tables for Poulkova, deduced from Peters's observations, were published in 1865; the entire series of observations previous to 1849 will probably be published within three years as a complete work, although the places of a number of stars in the original catalogue remain undetermined. From 1849 to 1863, the vertical circle was used by Döllen principally for observations of the sun, and in determinations of the declinations of stars used in the geodesic work of the Russian surveys. Since 1863 Dr. Gyldén has with this instrument directed his attention towards the standard stars of the Berlin and British almanacs; some observations upon Venus, made at her superior conjunction in 1865, are valuable as affording strong negative testimony on the question of the solar atmosphere; equally interesting are the thorough investigations made into the errors of the meteorological instruments used in connection with the vertical circle, and into the law of the decrease of temperature with increasing altitude above the earth's surface.

The *Principal Meridian Transit*, made by Ertel, at the east end of the west observing room, was designed, in connection with the Kessel normal clock, not only to give the time to the rest of the observatory, but also for the determination of the absolute right ascensions of some 300 fundamental stars; this latter number was increased to 400, and the prescribed series of observations was substantially finished in 1853. A preliminary series specially directed to the circumpolar stars had been made by Peters in 1840. New piers having been provided, the two meridian marks established, and the normal clock received, observations on the fundamental catalogue were begun by Schweizer and continued by him from 1842 to 1844; by Fuss from 1844 to 1847; by Lindhagen from 1847 to 1850; by Wagner from 1850 to 1857. In 1855 and 1856 the transit was used by Lindelöf in determining the right ascensions of stars used in the longitude expeditions. In 1860 the instrument was given into the hands of Mr. Brauer, the successor of Pohrt as the observatory instrument maker; several changes, including the regrinding of the pivots, were then made, and in 1865 the objective was mounted upon three points in order if possible to secure greater constancy in the collimation error. Since 1860 the redetermination of the 400 fundamental right ascensions has been undertaken by Wagner, and the series will probably be completed before 1870. The reduction of the observations previous to 1853, and the compilation of the resulting catalogue, are now finished; their publication may be looked for in the present year. The reduction of the second series (made with the transit since its improvement by Mr. Brauer, and recorded chronographically) progresses with the observations.

The reduction of the "eye and ear" observations having shown that the Houth-Wetzer clock in the west room, and the Kessel's normal clock originally placed in the central rotunda, were affected by the unavoidable changes of temperature, the former was replaced in 1861 by a dial connected by electricity with the normal clock, thus avoiding the laborious comparisons by chronometer that had been until that time carried on daily. In order to secure a still more uniform temperature the normal clock was then placed in an inner vault underneath the rotunda, where the daily thermometric term in the clock rate is quite imperceptible. Since 1862 the observations have been recorded upon a Krille's chronograph, which stands in a warmed room adjacent to the observing room, and differs from those in common use in America principally in that the observer's pen is independent of the neighboring clock pen, and in having a very convenient arrangement by which the observer at the transit can at will stop the revolving cylinder or set it in motion again. The clock automatic circuit-breaker is that of Krille. It consists of a thin vertical slip of mica at the extremity of a short arm attached at right angles to the upper portion of the pendulum, and in the plane of vibration; at every second the mica cuts through a small horizontal thread of mercury through which the electric current is passing. The Muston mean time clock was in 1866 connected with the central telegraph station in St. Petersburg, and regulates several sympathetic clocks. A noonday signal is also automatically given.

The exquisite small *Meridian Transit*, made by Brauer, and now found in an appropriate building southwest of the larger observatory, was used in the longitude expeditions to Dorpat, Moscow, &c., and has been employed by Fritsche in the series of lunar observations recently published by him in the Bulletin of the St. Petersburg Academy. A mate to this fine instrument is to be found at the naval observatory at Cronstadt. The five-inch Steinheil objective, mounted in 1866 parallactically in the east dome of the small auxiliary observatory erected in 1863, 100 yards south of the principal one, is intended to be used by Wagner in an investigation into the *relative parallaxes* of some of the brighter stars. The evidences of the extraordinary accuracy attained with the Meridian Transit are such as to justify the expectation that very decisive results will ensue from this renewal of the method so lately applied by Auwers to the determination of the parallax of 34 Groombridge.

The celestial photometry which has remained until lately in so crude a state, thanks to the labors of Steinheil, Seidel, and Zöllner, promises in future to rank as an exact science. An ingenious *Photometer*, invented and made by Professor Schwerd, of Speyer, was mounted in 1866 by Messrs. Smyssloff and Berg in the west dome of the auxilliary observatory, and offers a fine opportunity for research in a field that has as yet been but too little cultivated. A mate to this unique instrument has been ordered for the observatory of Bonn by Professor Argelander, who has signified his intention of devoting his future years to its use.

A little to the northeast of the central building is the convenient and tasteful observatory erected at the expense of the military academy, and furnished with a clock, a fixed transit, and very many portable instruments, together with very convenient arrangements for their use. This structure, completed in 1857, is of course exclusively for the use of the officers of the geodetic division of the Nicolas Military Academy whilst pursuing at Poulkova their course in practical astronomy. Among the works executed by these officers under Döllens's directions are several whose results may be looked for with general interest, such as the twelve repetitions of the measurement of a short base line, in the year 1865, and the observations made in 1866 for the investigation of the local attraction of the plumb line in the neighborhood of Poulkova.

In recounting the larger fixed instruments of the Central Observatory, we must not omit a few words concerning the smaller portable ones, of which the institution possesses several fine specimens of the best workmanship of Ertel, the

Repsolds, Brauer and others. These have found their most frequent use in connection with the geographic and geodetic labors conducted by its astronomers, of which we shall only mention the two grand international undertakings that have not as yet been surpassed in their magnitude—we refer to the measurement of an arc of latitude of 25°, and one of longitude of 69°. The former we have already frequently mentioned as being a work intimately connected with the foundation and the history of the first 25 years of the observatory's existence. The preliminary steps for continuing this work ten degrees further southward to the island of Crete are now being taken. To this meridian measurement that of an arc of longitude naturally forced itself upon Struve's attention as a necessary supplemental undertaking, and he had already, in 1848, prepared the way by enlisting the interests of General Wrontschenko, then engaged in the triangulation of the southern part of Russia. This original project of a measurement along the 47th parallel, as proposed by Struve in 1857, having failed of execution, Otto Struve in 1860 proposed the measurement of an arc from Valentia, in Ireland, eastward to Orsk, at the southern end of the Ural mountains. This work will be brought to a close this present summer—the future further prolongation of the line through Narvaul and Irkutsk to Nicolaieff may be confidently expected. The *Repsold Portable Vertical Circle* has been used in the latitude determinations on this measurement of an arc of longitude; the *Brauer Portable Extra-meridional Transit* has been adopted for the telegraphic longitude determinations, all of the latter being made by two observers, Dr. Thiele of Bonn and Captain Jalinski of Poulkova. The instruments, as well as the observers, exchange places during the season's work. We may, then, soon expect from this grand operation valuable additions to our knowledge of the curvature of the European portion of the earth's surface. The portable instruments alluded to merit more than a passing allusion. The Repsold Circle has been made the subject of an elaborate monograph by Smyssloff; a short notice of its construction and performance will be found in Silliman's American Journal for 1867. The Brauer's Transit has not as yet been similarly brought to public notice; this is owing to the fact that the few (six) that have been made by Brauer have been in continual use since they left his hands, but it is promised that this neglect shall be remedied ere long. These instruments, constructed at Poulkova at Döllen's suggestion, are specially adapted to use out of the Meridian, for which purpose nothing can be desired more convenient than the formulæ given by Döllen in his memoir entitled "Die Leitbestimmung," &c., "The determination of the time by means of a portable transit instrument established in the vertical of the Pole Star. St. Petersburg, 1863."

In connection with geodesy we must not omit to notice the *Base-measuring Apparatus* used in Struve's work, and now generally adopted by the Russian geodesists. This is distinguished by its simplicity and the facility with which it is used. Each piece is a plain bar of iron furnished at one end with a touch lever and enclosed in a packing of cotton within its wooden case; two interior thermometers and a reversible level complete the apparatus. With such means the rapidity and ease with which a base is measured compares favorably with that attained in other countries, and the accuracy of the results have never as yet, we believe, been called in question. One of the most interesting operations performed in connection with this base apparatus was the comparison with specimen bars used in other countries. This work, conducted during the interval 1850–54, has only been surpassed in magnitude by the more recent comparisons made at Southampton.

Among the geodetic apparatus worthy of special mention is the *Pendulum Apparatus* made by the Repsolds for the Central Observatory, and used since 1864 by Professor Sawitsch, who proposes to visit all the stations of the Russo-Scandinavian meridian arc. This apparatus may be defined as Bessel's symmetrical pendulum with reciprocal axes, being constructed according to the views of that

eminent astronomer as gathered from his well-known memoirs and his posthumous papers, published in the Astronomische Nachrichten, volume xxx. In this construction we find the effect of atmospheric resistance reduced to a minimum, and by the exchange of the knife edges the effect of their curvature may be eliminated. A mate to the Poulkova apparatus may be found at Geneva, and the complete investigations published by Plantamour demonstrate its excellence. The full publication of Professor Sawitsch's results will be looked for with the more interest because of the early attention paid in Russia to these matters. Preuss in Kotzebue's voyage of circumnavigation in 1822–28, and Parrot and Feodoroff in their ascent of Mont Ararat in 1830, were the first to attempt to directly measure the influence of mountains in causing local irregularities in the earth's attraction, if we except an almost forgotten and unpublished "pendulum survey" of the Harz and Brocken hills, by Zach, in 1797.

Finally, yet among the really most important instruments, we notice with great interest the many *chronometers* deposited at the Central Observatory, and continually being investigated there when not in use in the longitude expeditions. To their investigation Colonel Smyssloff has given very special attention, and to his results, as well as to the care with which they are used and their own intrinsic excellence, are to be attributed the accuracy of the longitude determinations annually made throughout the empire.

In closing this notice of the observatories of Dorpat and Poulkova, we cannot but revert to that very wide-spread but erroneous notion that astronomy is a science that of all others has least to do with the everyday wants of mankind. Such an opinion ignores that history which clearly points back through thousands of years to a long array of learned men who have hailed astronomy as the senior and protector of all learning. In the most ancient times the astronomer (and not merely the astrologer) was honored for his valuable services, but it was reserved for Greenwich and Poulkova to develop, each for itself, a path of usefulness through which to make its importance felt by the state. In so far as similar efforts are made by savants everywhere, they may rightfully look to the state for support: especially in this democratic country, where education is so widely diffused and useful science so liberally supported, is it the duty of investigators to show that the national progress consists not in the mere repetition to the children of that which their fathers knew, but in the actual INCREASE of knowledge.

ON TRACES OF THE EARLY MENTAL CONDITION OF MAN.

By Edward Burnet Taylor, Esq.

[From the Proceedings of the Royal Institution of Great Britain.]

If an antiquary is asked his opinion as to the early condition of mankind, he will probably take up the question with reference to an excellent test of man's civilization, the quality of the tools and weapons he uses. He will show how, within our own knowledge, the use of metal instruments has succeeded the use of sharpened stones, or shells, or bones; how the stone axes and arrow-heads found buried in the ground prove that in every great district of the world a Stone Age has prevailed at some more or less remote period; and lastly, how recent geological researches have displayed to us the traces of a Stone Age extraordinarily low and rude in character, and belonging to a time as extraordinarily remote in antiquity. The history of man, as thus told by a study of the implements he has used, is the history of an upward development, not indeed a gradual steady progress of each family or tribe, but a general succession of higher processes to lower ones.

Now there also exists evidence, by means of which it is possible still to trace, in the history of man's mental condition, an upward progress, a succession of higher intellectual processes and opinions to lower ones. This movement has accompanied his progress in the material arts during a long but undefined period of his life upon the earth; and of this evidence, and of the lines of argument that may be drawn through it, the object of the present discourse is to give a few illustrative examples.

I. In the first place, the *art of counting* may be examined from this point of view. We ourselves learnt to count when we were children, by the aid of a series of words, *one*, *two*, *three*, *four*, and so on, which we were taught to associate with certain numbers, 1, 2, 3, 4, and can thus reckon up to the largest imaginable number, and down to the smallest imaginable fraction. But if we look round among other tribes of men we find a very different state of things. As we go lower in the scale of civilization, it becomes easier and easier to puzzle a man with the counting of 20 objects, or even of 10, and to drive him to the use of nature's counting machine, his fingers. When we reach the low level of the savages of the Brazilian forests or of Australia, we find people to whom 3 or 4 are large numbers. One tribe, described by Mr. Oldfield, reckoned *one*, *two*, and then *bool-tha*, "many;" but when their poor word-language fails them they fall back on gesture-reckoning. Mr. Oldfield tells us, for instance, how he got from a native the number of men killed in a certain fight. The man began to think over the names, taking a finger for each, and thus, after many unsuccessful trials, he at last brought out the result by holding up his hand three times, to show that the number was 15.

Now our words, one, two, three, four, &c., have no etymology to us, but among a large proportion of the lower races numerals have a meaning; as among many tribes of North and South America and West Africa are found such expressions as, for 5, "a whole hand," and for 6, "one to the other hand;" 10, "both hands,"

and 11, "one to the foot;" 20, "one Indian;" and 21, "one to the hands of the other Indian;" or for 11, "foot 1;" for 12, "foot 2;" for 20, "a person is finished;" whilst among the miserable natives of Van Dieman's Land, the reckoning of a single hand, viz: 5 is called *puganna*, "a man."

For displaying to us the picture of the savage counting on his fingers, and being struck with the idea that if he describes in words his gestures of reckoning, these words will become a numeral, perhaps no language approaches the Zulu. Counting on his fingers, he begins always with the little finger of his left hand, and thus reaching 5, he calls it "a whole hand;" for 6, he translates the appropriate gesture, calling it *tatisitupa*, "take the thumb;" while 7, being shown in gesture by the forefinger, and this finger being used to point with, the verb *komba*, "to point," comes to serve as a numeral expression, denoting 7.

Now, though many numerals, especially fives, tens, and twenties, were named from the fingers, hands, and feet, this is far from being the only source of numerals. Many centuries ago, the Hindu scholars, besides their regular series, made a new set of words to serve as a sort of *memoria technica* for remembering dates, &c. Thus, for 1 they said "*earth*" or "*moon;*" for 2 "*eye,*" or "*arm,*" or "*wing;*" for 3, "*Rama,*" or "*fire,*" or "*quality*"—there being considered to be 3 Ramas, 3 kinds of fire, 3 gunas or qualities; for 4 "*age*" or "*veda,*" because there are 4 ages and 4 vedas. One line of an astronomical formula will show the working of the system:

vahni tri rtwishu gunendu kritâgnibhûta:

That is to say:

"Fire, three, season, arrow, quality, moon, four of dice, fire, element:"

That is 3 3 6 5 3 1 4 3 5.

When Wilhelm von Humboldt, more than 30 years ago, looked into this artificial system of numeration, it struck him that he had before him a key to the general formation of numerals. When a Malay, he said, calls 5 *lima*, that is, "hand," he is doing the same thing that the Hindu pandits did when they took "wing" as the numeral for 2; and then, he suggested, the numeral words having thus been once made, the sooner their original meaning was got rid of and they were reduced to the appearance of mere unmeaning symbols, the better it would be for their practical use in language. Now a number of actual facts may be brought forward in support of Humboldt's far-sighted suggestion. The Abipones of South America counted to 3, and for 4 said "ostrich toes," from the division of their ostrich's feet; then, for 5, "one hand;" for 10, "two hands," and so on. In Polynesia there is a regular set of decimal numerals, but sometimes, for superstitious reasons, they turn words out of their language for a time, and have to use fresh ones. Thus, in Tahiti, they ejected *rua* 2, and *rima* 5; and in a missionary translation of the Bible we find *piti* and *pae* instead; now *piti*, the new word for 2, means "together," and *pae*, the new word for 5, means "side."

In other South Sea islands, the habit of counting fish or fruit one in each hand has led to *tauna*, "a pair," becoming a numeral equivalent for 2; the habit of tying bread fruit in knots of 4 has made a new numeral, *pono*, "a knot," while other terms for 10 and 100 have had their origin from words meaning "bunch" and "bundle." And so, even in European languages, numeral words break out from time to time, ready to become proper numbers, should a vacancy be made for them in the now meaningless series, *one, two, three, four*. Thus in English we have *pair* or *couple* for 2, and *score*, that is "notch," for 20. The Letts count crabs and little fish by throwing them 3 at a time, and thus the word *mettens*, "a throw," has come to mean 3, and so in many other cases in other languages.

Now when tribes count by saying *hand* for 5, *take the thumb* for 6, *half a man* for 10, and so on, it is evident that the basis of their numeration is finger counting.

But there is also evidence in the systems of numeration of most civilized languages that they, too, are the successors of a rude unspoken system of gesture counting. The rule of the whole world is to count by fives, tens, and twenties; the exceptions are so late or so incidental that we may neglect them and say that the original counting of mankind is the quinary, the decimal, or the vigesimal system, or a combination of these. We need not go abroad for examples. In the Roman numerals, which count to V, and then begin again VI, VII, we have the quinary system. The decimal system is our familiar one. And when we speak of "threescore and ten," "fourscore and thirteen," we are counting by the vigesimal system, each "score" or notch, thus ideally made, standing for 20, for "one man," as a Mexican or Carib would put it. It is a very curious thing that both we and the French, having two good decimal systems of our own, should have run off into vigesimalism. Why should we have ever said "fourscore and thirteen" for the 93, which we have good Saxon tens to express? and why should they say in France, "quatre-vingt-treize," instead of holding to the Latin original of their language, and saying "nonante-trois?" The reason seems to be that counting by scores is a strongly marked Keltic characteristic, found in Welsh, Irish, Gaelic, and Breton, and has been taken up into the alien numeral systems of France and England. At any rate, the rule of the world is to count by fives, tens, and twenties; and the connection of this rule with the practice of counting on the fingers and toes will hardly be disputed. Indeed the remark has often been made that the fact of our having 10 fingers and 10 toes has led us into a system which is actually not the best; while if we had had 6 fingers on each hand, and 6 toes on each foot, we should probably have taken to using, like the carpenter, the more convenient system of duodecimals.

These are examples of the facts which tend to show that man's early way of counting was upon his fingers; as Massieu, the Abbé Sicard's celebrated deaf and dumb pupil, records in describing his recollections of his yet uneducated childhood: "I knew the numbers before my instruction; my fingers had taught me them. I did not know the ciphers. I counted on my fingers." Among the lower races, the use of word language has only to a small extent encroached upon gesture language in counting; among races above these, numeral words are more largely used, but preserve evident traces of a growth out of gesture counting; while among the higher peoples, though language gives little trace of the original signification of numerals, there still prevails the system of counting by fives, tens, and twenties, of which we can hardly doubt that the norm is given by the arrangement of the fingers and toes. Thus it appears that in the mental history of mankind we may see back to a condition so much lower than our own, that the numerals, which we look upon as so settled a part of speech that we use them as one of the first tests of the common derivation of languages, were still unspoken, and their purpose was served by the ruder, visible signs which belong to the department of gesture.

II. The next argument to be brought forward belongs to a very different province of thought, and touches on the early opinions of mankind as to the *nature and habits of spiritual beings*. It is well known that the lower races of mankind account for the facts and events of the outer world by ascribing a sort of human life and personality to animals, and even to plants, rocks, streams, winds, the sun and stars, and so on through the phenomena of nature. It is also known that a low stratum of the religion of the world consists in belief in, and adoration of, spiritual beings who inhabit the winds and trees and streams, who preside over the ripening of fruits and the falling of rain, give success in war, or inflict disease or misfortune on the savage hunter. Thus the Mintira, a low tribe on the Malayan peninsula, ascribe every ailment that happens to them to a spirit or *hantu*. One causes smallpox, another brings swelling and inflammation in hands and feet, another causes the blood to flow from wounds; indeed, to enumerate all these *hantus* would be to give a list of all their known ailments.

The worship of such spirits, found among the lower races over almost the whole world, is commonly known as "fetichism." It is clear that this childlike theory of the animation of all nature lies at the root of what we call mythology; if the sun and moon are described as semi-human beings, called by the Greeks Helios and Selene, by the Esquimaux Anninga and Malina, this personification is founded on an original opinion still found in lively existence in the world, that the sun and moon are living Anthropomorphic creatures. It would probably add to the clearness of our conception of the state of mind which thus sees in all nature the action of animated life and the presence of innumerable spiritual beings, if we give it the name of animism instead of fetichism. Now, by examining a single phase of this animism, it seems possible to give some idea how generally man in his lowest known state of culture is a wonderfully ignorant, consistent, and natural spiritualist; and also how the effects of his early spiritualism may be traced through the development of more cultured races in proceedings which have often changed their meaning, and lost their original consistency by the encroachment of mroe real knowledge.

We all know how deep and sincere is the terror of ghosts among savages. It is often no exaggeration to say that they are in more deadly fear of a man after he is dead than while he is alive. The savage's notion of a ghost corresponds very nearly with that of the English peasant in our own day—it is a thin phantom going from place to place, like the person it belonged to, when it does appear, but often invisible, though capable of knocking and uttering sounds. The notion of the ghost runs almost inextricably into that of the spirit or soul, of the breath and the blood, and of those unsubstantial somethings which follow the man and are like him, his shadow and his reflection in the water. Now it is consistent with this opinion of ghosts to hold that by killing a man you can release his ghost and send it where you will. This is what the King of Dahome does when he sends men day after day to take messages to his father in the land of shadows. The Getæ, according to Herodotus, sent a man every five years to their god Zamolxis, giving him their messages, and then throwing him up and catching him on their spears. Thus, in British India, some 80 years ago, it is on record that two Brahmins, believing that a man had taken 40 rupees out of their house, took their own mother and cut her head off, that her ghost might torment and pursue to death the offender and his family—the old woman being herself a consenting party to the transaction. This is not an isolated case, but one belonging to a recognized Hindu practice.

In perfect accordance with this opinion we find in almost every country in the world, at some time or other, the practice of slaying men and women at the graves of the dead. In one of the South Sea Islands a cord is put round the wife's neck at her marriage, and when her husband dies it will be tightened, to release her soul, that it may accompany his to the land of shadows, and continue to catch fish and cook yams for him there. The Dyaks, of Borneo, have a passion for waylaying their enemies and bringing home their heads; as they told Mr. St. John, "the white men read books, we hunt for heads instead." They do this to secure the services of a slave in the next world. These practices are the consistent working out of a spiritualistic theory, which, if crude and false, is at any rate intelligible. To some extent the same may be said, when not only the dead man's wives and slaves, but his dogs and horses are killed, and buried or burnt at his grave. The man's ghost is to ride the horse's ghost in the land of shadows, and the dog's ghost will run on before after ghostly game; or, as in Mexico, the dog was to carry the man across the river which lies between the world of the living and the world of the dead; while in Greenland, a dog's head was placed by the grave of a little child, that the soul of the dog, who ever knows his way home, might guide the helpless infant to the land of spirits.

But when not only men and animals, but inanimate objects are buried or burnt for the dead, what does this mean? When the hunting tribes of North America

provide the dead man with his favorite horse, and at the same time with his bow and arrows; while the fishing tribes bury the dead man in his canoe, with the paddle and the fish spear ready to his hand, what difference can we discern between the purpose of the animate and of the inanimate offerings, which alike are to serve the spirit of their owner? When the dead chief's wives and his slaves, his horses, his weapons, his clothes and ornaments, are indiscriminately buried with him; when food is put in the grave with the dead man, and fresh supplies brought every month; when the little child is provided with its rattle and playthings, and the dead warrior has the ceremonial pipe put in his hand, that he may hold it out as a symbol of peace when he comes to the other world, while a store of paint is buried with him that he may appear decently among his brother warriors; in these and hundreds of other instances, the spirit of the dead man is to use the spirits alike of men and animals, and of weapons, clothes, and food. Then we should expect savages to be found recognizing the existence of something of the nature of a spirit or ghost belonging to inanimate objects; and this in fact they do.* The existence of the Fijian opinion is well authenticated, that lifeless objects have spirits, and that the souls of canoes, houses, plants, broken pots, and weapons may be seen floating down the river of death into the land of souls; and crossing into North America we find the same idea, not only that souls are like shadows, and that everything is animate in the universe, but that the souls of hatchets, kettles, and such like things, as well as of men and animals, have to pass across the water which lies between their home in this life and the Great Village where the sun sets in the far West. We must not expect the spirits of spears and kettles to have the same distinctness and vitality in savage philosophy as the spirits of men and horses. Inanimate objects want those signs of life that are given to men and animals by the breath, the blood, the independence of voluntary action; but at any rate they have shadows, as in the New Zealand tale of Te Kanawa, who offered the fairies his neck ornament and ear-rings; they took the shadows of them, but the substance they left behind. They have also that property which in the mind of the savage has so much to do with defining the nature of ghosts—their impalpable phantoms can and do appear far away from where their real substance is, in the dreams and hallucinations which savages look on as real events. When we meet with notions of apparitions among more civilized people, it seems that they hold a theory inherited from the full animism of the lower races, but much damaged in its consistency by the interference of a better knowledge of facts. When the ghost of Hamlet's father appeared, he "wore his beaver up." What beaver? To an European believer in ghosts, it would seem foolish to talk of the ghost of a helmet; but to a North American Indian it is quite reasonable that a helmet should have a ghost as well as the warrior who puts it on his ghostly head. The opinion of the European ghost-seer is no doubt the more scientific, the more affected by knowledge of the facts of nature; but the broader spiritualism of the savage is more full, more thoroughly consistent, because, as there is much reason to think, it is nearer to its source.

A slight acquaintance with the spiritualism of the savage has sometimes led to its being considered as the result of a degeneration from the opinions of more cultured races; but more complete knowledge of the facts tends to show that such an opinion inverts the real history of events. The way in which the fullest and most consistent theory of ghosts is at home among savage tribes is well shown by the belief that the spirit arrives in the next world whole or mutilated, according to the condition of the body at death. For instance, there is an Australian tribe who believe that if a man be left unburied, his soul becomes a wandering ghost. If one of their warriors kills his enemy, he is sometimes

* The speaker mentioned that he had just found in the works of an American writer, Mr. Alger, independent confirmation of the view he had taken of the savage theory of spirits, as including spectres of inanimate as well as of animate objects.

embarrassed with the difficulty that by so doing he is setting free a hostile ghost to vex his own people, and therefore he resorts to the device of cutting off the dead man's right thumb, so that the ghost can no longer throw his spear, and may be safely left to wander as an evil spirit, malignant, but harmless. The history of the very funeral offerings just spoken of shows in the most interesting way the progress of a ceremony from its source in a crude and savage philosophy to its gradual breaking down into mere formality and symbolism. To the Aryan of the Vedas it was quite reasonable to burn the priestly sacrificial implements with the dead man's body for his use in the next world; but the modern Hindu lays one thread of woollen yarn on the funeral cake of his father, saying, "May this apparel, made of woollen yarn, be acceptable to thee!" We may learn from Ovid how the offerings of food to the dead, in ruder times a thorough practical savage proceeding, had in his time dwindled to a mere affectionate, sentimental ceremony. Garlands, he says, and some scattered corn and grains of salt, and bread steeped in wine, and violets laid about: with these the shade may be appeased. "Little the manes ask, the pious thought stands instead of the rich gift, for Styx holds no greedy gods."

"Parva petunt manes—pietas pro divite grata est
Munere. Non avidos Styx habet ima deos."

We may see how the early Christians kept up the heathen custom of burying ornaments with the dead, of putting playthings in a child's grave, doing just what a red Indian squaw will do, but doing it with how changed a purpose. The Chinese keeps up the time-honored custom of providing the dead with clothes and money; but the money that he will palm off on his dead father is a pasteboard coin, stamped like a Spanish dollar, and covered with silver-leaf; this he will burn, and his father will have the spirit of it to spend in the next world. The same Chinese will yearly spread a feast for the souls of his dead ancestors; he and his friends will wait a decent while for the ghosts to eat the spirits of the food, and then they will fall to themselves. To see the same thing done nearer home, you have only to travel into Brittany, where on the night of the Fête des Morts you will find the fire made up and the hearth swept, and the supper left on the table for the souls of the dead to come and take their part. And when we see a wreath of everlastings laid upon a tomb, or a nosegay of fresh flowers thrown into an open grave, a full knowledge of the history of funeral offerings seems to justify us in believing what we should hardly have guessed without it, that even here we see a relic of the thoughts of the rudest savages who claim a common humanity with us, a funeral offering vastly changed in signification, but nowhere broken in historic sequence.

Lastly. Another subject may be found to throw light upon an early condition of men's minds. We are all agreed that there is a certain mental process called the *association of ideas.* That we are in the habit of connecting in our minds different things which have, in actual fact, no material connection, we all admit as a matter belonging to this association of thoughts or of ideas. Now we have been taught to keep an eye on the action of the association of thoughts, to recognize it as a fallacious process apt to lead us into all manner of unreasonable opinions. But if we descend to a lower range of civilization, we shall find that the mental association which we tolerate as a sort of amiable weakness, and against which we are at any rate forewarned and forearmed, is the very philosophy of the savage. There is one particularly excellent way of studying the effects of the association of thought. It began to produce, in a time associated with a very low human condition, a set of opinions and practices known as the occult sciences, witchcraft, divination, astrology, and the like. The germs of these imaginary sciences are to be found still lively among the lower races. Their development into elaborate pseudo-scientific systems belongs to a period now beginning to pass away; and we can still study them in their last stage of existence, that in which their remnants have lingered on into a period of

higher mental culture, and have become survivals, or, as we call them, "superstitions." In producing the occult sciences, the association of thought works in ways most distinctly recognizable. When the Polynesian weather-maker practices on his sacred stone, wets it when he wants to produce rain, and puts it to the fire to dry when he wants dry weather; and when, in Europe, water is poured on a stone, or a little girl led about and pails of water poured on her that rain may in like manner be poured down from the sky, we have practices resting on the most evident and direct association of thoughts.

Thus we may see a Zulu busy chewing a bit of wood, and thereby performing an ideal operation, softening the heart of another Zulu with whom he is going to trade cows, that he may get a better bargain out of him. So it is when we find lingering in England a practice belonging thoroughly to the savage sorcerer, that of making an image representing an enemy or part of him, and melting it, drying it up, or wounding it, that the like may happen to the person with whom it is associated. From time to time there is still found hidden about some country farm such a thing as a heart stuck full of pins, the record of some secret story of attempted magic vengeance.

In the ancient and still existing art of astrology we see the same early delusive association of ideas producing results so perfectly intelligible to us that it is really difficult for educated people to have patience to study its details. An astrologer will tell us how the planet Jupiter is connected with persons of a bold, hearty, jovial temperament; and how the planet Venus has to do with love and marriage; while to us the whole basis of this theory lies in the accident of the names of certain gods having been given to certain stars, which are therefore supposed to have the attributes of these gods. The wonder is not that much of the magician's sham science is inexplicable to us, but that the origin of so many of its details is still evident.

[An extract from Zadkiel's almanac was here read, with the object of showing the principle on which the astrologer's deductions are still made, the movements of the heavenly bodies being simply taken to symbolize human action, virtue and good fortune being connected with the aspects of the sun and Jupiter, (sunny and jovial influences,) &c., the working of the early childlike principle of the association of ideas being thus traceable through the occult sciences from their rise among savages to their decay among educated men.]

By the study of facts like those of which a scanty selection has here been brought forward, it seems possible to look back to an early condition of our race much more nearly corresponding with that of existing savages than with that of the civilized nations even of very ancient times. We seem to have before us the traces of a state of language so low that words for counting had not yet arisen in it, but mere gesture-language served their purpose. It is not meant to imply that we have evidence of a state of pure gesture-language anterior to any spoken language; we do not seem to have such evidence, and even among the lower animals we find, in a rudimentary form, expression by action and by voice going on together. In the working of the minds of these early tribes, we trace a childlike condition of thought in which there is a wonderful absence of definition between past and future, between fact and imagination, between last night's dream and to-day's waking. Out of this state of mind we find arising all over the world a consistent, intense, and all-pervading spiritualism to form a basis upon which higher intellectual stages have been reared. In this low and early mental state there reigns supreme the faculty of association of thoughts. Out of this, when unchecked by experience, arise those delusions of sorcery which pervade and imbitter the whole life of the savage, and carry a stream of folly far on into the culture of the higher races. But through age after age there has gone on a slow process of natural selection, ever tending to thrust aside what is worthless, and to favor what is strong and sound. Wilhelm von Humboldt, already once quoted, may serve us again by laying down in few

words one of the great generalizations of our intellectual history. "Man," he says, "ever seeks the connection, even of external phenomena, first in the realm of thought; * * * * his first endeavor is to rule nature from the idea outward."

Now if the result of inquiries like the present were to bring out mere abstract truth, barren of all practical importance, this would perhaps be the last place where it would be needful to apologize for the want. But it is to be noticed that they do happen to have this practical importance. There are certain studies which have entered upon a thoroughly scientific stage, and ask no aid from ethnographic research; they care nothing for the crude theories of earlier times, but go directly to their own observed facts by which they must stand or fall. But there are other studies, of not less importance to us than astronomy or chemistry, which are in a very different state. In such especially as relate to man, the operations of his mind, his relations to the rest of the universe, the past and future condition of his race, his ethical and political rights and duties—in all these complex and difficult problems we find established side by side sources of opinion of very different value. Some opinions come to us authorized by the best of evidence, and when put to the test of reason and experience the trial proves their soundness. Others again, though founded on some crude theory of less educated times, have been so altered in their scope and meaning by the lessons of experience, as to be on the whole the best known representatives of facts, and by this not unsatisfactory title they hold their ground. Others, lastly, may arise out of opinions belonging to a low stage of culture, and maintain their place, not because they are proved to be true or useful, but simply because they have been inherited from long past generations. Now it is one duty of ethnographic research to follow up these lines of thought, to mark out, among existing opinions, which are old notions kept up in a modified condition to answer a more modern purpose; in what cases a growing knowledge goes about with the remains of the old philosophy which once clothed it, now hanging in strips and tatters about its back; in what case opinions belonging to a low and early mental state survive into the midst of a higher culture, pretending to be knowledge, and being really superstition. Thus the study of the lower races has a work to do in facilitating the intellectual progress of the higher, by clearing the ground, and leaving the way open for the induction of general laws and their correction by the systematic observation of facts, to the results of which method alone we may fitly give the name of Science.

ETHNOLOGY.

INDIAN REMAINS NEAR RED RIVER SETTLEMENT, HUDSON'S BAY TERRITORY.

By Donald Gunn.

Red River, *April* 1, 1867.

I have been collecting a few Indian relics of former ages, such as stone axes, mallets, and skulls. The axes are made of a fine-grained blue-stone, the mallets of gneiss; the skulls were taken from what are apparently sepulchral mounds. Last October a neighbor living on the east side of the river, requiring an additional cellar to preserve his root-crop from the winter frosts, commenced digging into the top of a knoll in the woods, close to his field, taking out eight feet square. He did not dig precisely into the centre of the knoll, but somewhat to one side; on digging down he was rather surprised at the depth of the surface-soil, or black vegetable mould, being so much greater here than he had ever found it anywhere else; he, however, continued digging until he got from four to five feet deep. Here he began to cut through decayed wood, apparently oak, which had been laid in a horizontal position. On getting a foot or so below this, in paring down the side of the pit, he uncovered a human skull, having its lower jaw attached, and lower down the vertebræ, showing that the dead had been placed in a sitting posture. In digging still further, he found other human remains, and at a depth of eight feet from the top of the tumulus and on a level with the surface of the surrounding country he struck on a floor of very smooth and hard white mud, which appeared to have been hardened by the action of fire, since bits of coal were found on it. On this clay flooring the following articles were found, viz: four or five skulls lying on the face; a number of small bones, those of fingers and toes; an earthen kettle, with a shell in it, such as live at present in this river; bones of the beaver; two pipes of fine blue-stone, without a perforation; three ornaments made of shell or bone—two of them, I think, of the shells probably of the small turtles found here in the river; the other must be of bone and is about five inches in length; one perforated shell, used for ornament; a few beads, made of shell.

There is another tumulus 400 or 500 yards directly south of this. It is larger than the one that has been opened, and I think that if opened something interesting would be found in it. These mounds have been known for many years past, but never supposed to have been works of art, or raised by human labor; but now I begin to entertain the opinion that many such sepulchral mounds are to be found in this vicinity.

The Indians dwelling in this section of the country have no traditional knowledge relating to these mounds; when any questions are put to them as to the time when erected, and the use for which they were raised, they answer that they were mud dwellings, such as are occupied at present by the Mandans on the upper Missouri; and that they had been built very long ago; who the builders were they know not.

This ignorance of former times can, to some extent, be pretty satisfactorily accounted for from the well-known fact that this region has often had a change of inhabitants since the advent of the whites. The Crus were in possession when the first traders found their way to Lake Ouinipeg, as they then called it. The Assinaboines succeeded the Crus, on the latter tribes breaking off or sep-

arating from their kindred, the Dakotás. The Santena or Ojibois followed in the wake of the traders from Canada, chiefly in the last decade of the last century. If ever the Crus or the Assiniboines deposited their dead under mounds of earth, they discontinued that mode of interment long before the advent of the whites, otherwise both missionaries and traders must have seen and recorded the custom, or at least some traces of it. In the absence of all testimony we are led to the conclusion that they are monuments of considerable antiquity, and that the race who constructed them, and whose remains they cover, have passed away ages since or become mixed up with a race or races, if not more barbarous, evidently less energetic and industrious, who did not manifest their affectionate regard for the dead by performing so much labor in covering their remains. May we not with some reason conjecture that the object for which these mounds were heaped up with so much toil was to transmit to generations then unborn the fame of some renowned patriot or chief who led the warriors of his tribe to combat against encroaching foes, and who was victorious in the strife? The first thought that occurs to the mind in examining these tokens of mortality is that they were in course of erection during a long period of time; that succeeding generations took each a share in the work; buried their dead over those who had been deposited before them, and added their share to the earth until the mounds assumed their full dimensions, or the practice of this mode of interment fell into disuse; yet, on reflecting over the subject, I am disposed to come to the conclusion that these mounds were raised over the remains of men who stood high in the esteem of their family and tribe; who labored to build their tombs from the laudable motive of perpetuating the memory of friends and benefactors. The tombs might have been reopened from time to time to receive the remains of the family or kindred of the first occupier to whose memory it had been erected, down to periods of time much more recent than their origin; or the Indians might prefer interring in these mounds, finding them dry and easier to excavate than the surrounding soil; such seems to have been the case in regard to the great tumulus on the west side of this river. Some time about 1786 the small-pox spread over what is now known as Hudson Bay territory, carrying off the natives by thousands. The Crus at that time occupied this vicinity. I have seen and spoken to an old man, the only survivor out of many tents, who stated that at the commencement of the mortality the Indians, for some time, buried in the mound above described, but did not erect it, and that at a later period of the disease the living did not attempt burying the dead.

Up to the last years of the last century the Indians on the western shores of Hudson's bay occasionally disposed of their dead by placing them on scaffolds or stages. I am not aware that they ever returned to look after the bones for the purpose of interring them. The Indians occupying this part of the country at present inter the dead, but never, to my knowledge, in a sitting posture. They press the knees up towards the chin—in a word they roll up the dead into the smallest possible space, open a shallow grave, lay the body on its side, with the face generally towards the east. The Assiniboines still continue the custom of laying their dead on stages.

I trust that you will let me know if the Institution is desirous of having any of those antiquities of which I have written, viz: skulls, pipes, ornaments, &c. If they are desired, I will search into some other mounds in this vicinity and send whatever I find that may appear worth the cost of transportation.

The winter has been late in setting in; we had very little snow before the beginning of January. We have had very little snow in the settlements; but it is spoken of as being very deep towards the Lake of the Woods and in the plains towards the Missouri. The cold has not been extremely intense, but very regular; this is the 22d of March, and we have not had as much thaw as to wet the soles of our moccasins.

ANCIENT MOUND NEAR CHATTANOOGA, TENNESSEE.

By M. C. Read.

The mound from which the specimens sent you were taken is situated on the left bank of the Tennessee river, above Citico creek, and about one mile from Chattanooga. It is on the rich alluvial land bordering the river, and so situate on the outer side of a curve of the stream as to be readily seen by parties coming up or down the river, as well as by any one approaching the valley over any of the hills and mountains by which Chattanooga is surrounded. Directly east of it is the site of an ancient pottery and manufactory of flint arrow-heads, several acres being covered with fragments of broken pottery, burned clay, chippings of flint and arrow-heads, many of them apparently spoiled in the hands of the manufacturer. Broken stone hammers, stone and earthenware pipes, flat circular disks of the size of large checker-men, made of stone, pottery, and occasionally of hard, mineral coal, are frequently found. The place where these are found has been for years under the plough, but, on digging to the depth of eighteen inches or more, ashes and coal, amorphous masses of burned clay, fragments of bones, and abundance of broken pottery, are found. This is all of a coarse character; the various attempts at ornamentation being rude and inartistic. The material used was the earth taken from below the surface and filled with finely comminuted fragments of river shells. The surface is covered with these shells, many of them in a good state of preservation, of the same character with those found more abundantly down the river at Shell Mound and other places, and all identical with the species still existing in the river. These facts are of especial interest on account of their bearing upon the relative age of the mound. This one is of an oval form, with a base of 158 by 120 feet; the larger diameter being upon the true meridian, or as near it as we could determine by an ordinary pocket compass. The dimensions of the top, which was substantially level, are 82 by 44 feet, and the height 19 feet.

For purposes of examination, and to provide the gardener of the Sanitary Commission, who had his office on the mound, with a place to store vegetables for spring planting, a tunnel was excavated into the mound from the east, a little one side of the centre, and on a level with the natural surface of the ground. When the point directly under the outer edge of the top of the mound was reached, holes were found containing fragments of rotted wood, showing that stakes or palisades had been erected here when the mound was commenced. The sound of the pick indicating a cavity or different material below, the excavation was carried downward about two feet, when two skeletons were uncovered, fragments of which, preserved, are marked No. 1. The bones were packed in a small space, as though the bodies were crowded down, without much regard to position of hands, into a pit not exceeding three feet in length. One of the skulls is of especial interest, as possibly indicating that the remains are those of victims immolated in some sacrificial or burial rites. The side was crushed in, as if with a club. I have connected together the pieces of the upper jaw, so that they retain the position in which they were found, a position which cannot, with probability, be supposed to be the result of the settling of the earth around it, if unbroken when buried. The bones of the bodies, although so friable that they could not be preserved, were entire, in positions indicating that the bodies had not been dismembered, and forbidding the supposition that they were the remains of a cannibal feast.

The excavation was carried forward as indicated on the plat, and on a level with the location of the skeletons first found. It became evident at once that the material of which the mound was constructed was taken from the immediate neighborhood; it being composed of the same alluvial soil, full of the shells found on the surface, but in a much better state of preservation; but no arrow-heads,

chippings of flints, or fragments of pottery, now covering the surface, were found. These would have been abundant if the mound had been erected subsequently to the manufacture of the pottery and arrow-heads at that place. Single fragments of pottery were found, but these were painted and of much better quality than those found upon the surface.

The mound was composed of alternate layers of earth and ashes, showing that a surface of the size of the top, when finished, was kept substantially level, and raised only two to three feet at a time when fires were kindled, which must have been large or continued for a long time, as the amount of the ashes and fragments of charcoal abundantly indicate.

Near the centre of the mound rows of stake-holes were found, as far as followed, marking two sides of a rectangular parallelogram, which, continued, would have formed an enclosure around the centre. In some of these were the remains of the wood and bark; not enough to show the marks of tools if any had been used. They penetrated the natural surface of the ground to the depth of about two feet.

Here, and at about the same level as at No. 1, were found the skeletons of which the skull-bones and other parts are marked No. 2. They were apparently the remains of a youngish woman and two children, all so far decomposed that only the parts sent could be preserved. The larger skeleton was in such a position as a person would take if kneeling down, then sitting upon the feet, the hands were brought to the head, and the body doubled down upon the knees. The head was toward the south. The remains of the children were found at the right side of this body, the bones mingled together.

About two feet directly under these, the skeleton, of which the skull is marked No. 3, was found in a similar position, it is said, (I was not present when it was taken out,) with the one above it.

I attempt no description and indulge in no speculations in regard to these remains, as I have decided to forward them to you, for the examination of those who can compare them with other skulls, and are better qualified to make a proper use of them. They are unquestionably of the age of the "mound builders."

I enclose also, marked No. 4, remains taken from between two flat stones near the surface of the mound at point marked No. 4. These are doubtless of Indian origin.

I enclose also a poor photograph of the mound after it had been cleared and ornamented by the gardener, showing his office, arbors, seats, &c., on the top, and guards and laborers in front. It will serve to give you the outline of the mound.

It was my purpose to continue the examination further; to follow round the line at No. 1; ascertain whether other bodies were buried in a similar position; to look for a completion of the parallelogram at the centre; to carry a shaft upward to the top, and connect and measure the successive layers of earth and ashes; but the simultaneous firing of the heavy guns in the forts about Chattanooga, at the celebration of Lee's surrender, produced such a shock that the mound "caved in," burying tools, vegetables, &c., to be found, perhaps, by some future explorer, as proof of the intelligence of the race of the mound builders. No other works are found in the neighborhood, but I obtained verbal information of very many mounds, stone forts, rock inscriptions, &c., &c., in the State, a careful examination of which might throw much light upon the character of a race who have left no other records.

ANCIENT BURIAL MOUND IN INDIANA.

By William Pidgeon.

At Vincennes, Indiana, in 1859, in the removal of a battle burial mound, I noticed features altogether unlike any I had previously seen. It seems not only to have been used as a deposit for the fallen warriors, but also as a place in later times where bodies were consumed by fire. That this was a custom of the mound builders for many ages I have no doubt. This mound was removed from a plat of ground owned by Hasselback & Co., in the suburbs of the city, and occupied as a distillery stock-yard. It was larger than mounds usually are of that description, and at the time of its removal it had a diameter at the base of 66 feet and a perpendicular altitude of 16. I think it was originally more pyramidal in form, its expansion at the base having been increased by the tread of animals. It has frequently been observed in the forest, where civilization has not yet reached, that the battle burial mounds have an altitude of about one-third of the diameter of the base. This mound, however, was the place of resort, for two years, of several hundred hogs and cattle, enclosed within less than three acres, although the surface, destitute of vegetation, seemed to resist all impressions from the horns, hoofs, or snouts of the animals. It was removed in a manner that favored the most critical investigation. The excavation, beginning at the south side of the base, was continued on a level to the opposite side, presenting, in well-defined outline, four separate stratifications above the first, which consisted of a bed of human bones, arranged in a circle of 18 feet in diameter, closely packed and pressed together, so much so that it was with difficulty that we raised from the entire mass two leg-bones retaining their primitive length, which was twenty-seven inches. Others longer and shorter were seen, but could not be disinterred. Around the outer edge of this circle the stratum was thinner than in the centre; skulls, legs, rib and back bones lying promiscuously mingled, indicating a pile of bodies thrown together in pyramidal form. This deposit was covered with a stratum of tough, grayish clay, that resisted saturation almost as well as tallow; the stratum of bones and clay each being thirty-three inches in depth at the centre, the clay retaining its thickness throughout. The third stratum was composed of earth that seemed to be formed of ashes, with an occasional speck of calcined bone throughout the entire mass, but abundant near the centre. Above this was a twelve-inch stratum, resembling the subsoil around the mound, the whole being covered with clay that resists saturation to an extent that, if protected by grass, would resist the elements for centuries.

ANCIENT REMAINS IN COLORADO.

By E. L. Berthoud.

May 21, 1867.

About half a mile west of Golden city, Jefferson county, Colorado Territory, and near the entrance of the cañon of Clear creek, are ruins, formed of an old broken down circumvallating circle of rough stone derived from the neighboring mountains and a sandstone ridge south of them. These ruins are at the junction of a ravine ten feet in depth and the bed of the creek, which is about twenty feet vertically below the wall. A large amount of stone has been taken for foundation walls, &c., but enough remains to give an outline of its position and shape. The stones are in many places imbedded in the soil and mossy with age. On the south side is a pit twelve feet wide and about fifteen to eighteen inches deep, shaped like a saucer. The central mound, very plainly discernable, is nowhere

over one foot high, is formed of granitic sand, and around its circumference are the evidences of five or six shallow pits, surrounded by a stone enclosure now almost all gone and traced by broken fragments of stone, burnt bones, &c. Both in the central mound, in the outer wall, and in the soil of the neighboring pits and ridges, are many old decayed bones of buffaloes, fragments of antlers, &c. No human remains, nor any tools, weapons or utensils of any kind, except two flint fragments and a number of plates of mica, were discovered.

MOUNDS IN MISSISSIPPI.

By Samuel A. Agnew.

Guntown, Miss., *January* 11, 1868.

While reading the article on "the ancient earthworks in the United States," in the appendix to the Smithsonian Report for 1866, I thought that perhaps I might be able to furnish some facts relating to this general subject which might perhaps contribute something to those engaged in the study of ancient Indian remains, and I venture to forward them to the Institution, although I am uncertain whether or not what I may state is unknown to those pursuing such studies. Dille remarks "no earthworks of any kind were seen by him in Mississippi." I am a citizen of that State and have resided here fifteen years, and being a minister of the gospel have had occasion to visit different sections of this portion of the country. During my peregrinations several mounds have attracted my attention, and I will proceed to note down the localities of those and of others of which I have some knowledge. I should state that when I mention the height, circumference, or area of mounds, the figures are not the result of measurement but of an estimate made from their appearance.

The following comprises a list of some of the mounds in this portion of the country:

No. 1. On the land of Joseph Agnew, on Camp creek, in the southeastern part of Tippah county. It is about ten feet high and has several trees growing on it. It has never been dug into.

No. 2 is near James Wiley's, in Pontotoc county, six miles west of Ellistown. It resembles in appearance and is about the same height as No. 1.

No. 3 is near John M. Simpson's, five miles southeast of New Albany, in Pontotoc county. The road cuts into one side of it. The elevation above the surface is six or eight feet. Human bones were found in this mound.

No. 4 is on the north side of Tallahatchie bottom, on the road from New Albany to Ripley. Its top has been flattened, and when I last saw it, eight years ago, a neat little residence was on the summit.

No. 5 is a large mound in Pontotoc county, near the residence of William Parkes, between Butchiecunifila and Oconitahatchie creeks, about ten miles southwest of New Albany. It is quadrangular, with a flat top, and contains, I suppose, as much as a half acre of level land on its summit. It is from ten to fifteen feet high and I think has not been examined for remains.

No. 6 is in Tishomingo creek bottom, near Dr. Selman's farm, five miles west of this place. Its summit embraces an area of from one-quarter to half an acre. Trees are growing on its surface. I did not ascertain its height.

No. 7 is on the same creek, near Duncan Clark's, ten feet high, and about thirty feet in diameter.

No. 8, near Mr. T. A. Sullivan's, in the same vicinity, is another mound ten feet high. Two large post oaks are growing on its top. It was dug into several years ago and a bed of ashes was reached, when further excavations ceased.

No. 9 is a mound which was on the Fane place, in the same neighborhood, the surface of which was cultivated. In 1860 a silver thimble was ploughed up on this mound, which is in possession of Dr. Selman of this place. He says that it is much larger than ordinary-sized thimbles, and is of the opinion that it is a relic of past times evidently of a civilized people.

No. 10 is a mound in Mr. Longbridge's farm, near Birmingham, the surface of which is cultivated, which was dug into eight or ten years ago, and pieces of pottery with strange figures on them discovered. Silver ear-rings were taken from some ancient graves adjacent to it. All of these mounds, from No. 6 to No. 10 inclusive, are situated from five to eight miles west of this place.

No. 11 is a mound two miles above Baldwyn, and within fifty yards of the Mobile and Ohio railroad, of considerable size. An Irishman dug into it just previous to the war, but I have not learned the result of his explorations.

No. 12 is a mound six miles southeast of No. 11, on Michenor's near Manatachie creek, thirty or forty feet in circumference. A hickory tree two feet in diameter grows on its top. The mound is eight feet high.

No. 13 is a large mound near Knight's mill, in this county (Lee.) Its summit contains about half an acre; a dwelling and well is on the mound.

No. 14 is a small mound near Dr. Maas, two miles east of Ellistown, eight feet high, which has a red oak growing on it, three feet in diameter.

No. 15 is a mile south of Guntown, on the Mean's farm, sixty yards in circumference and eight or ten feet in height. It is cultivated.

No. 16 is a group of some seven or eight mounds, in Twenty-mile creek bottom, at a distance of from eight to fifteen miles east of this.

No. 17. I have heard of another mound which I ought not to omit to mention. It is on the bottom (low ground) of Yorribie creek, three miles south of Birmingham, on the lands of John A. McNiel, said to be one hundred feet high, and covers an are of a half acre. Large trees are growing over it from three to three and a half feet in diameter.

No. 18. Near this mound, in the same creek bottom, are two other mounds, large, on the lands of a New York land company.

From all the information I have obtained, I believe that there are multitudes, I might truly say hundreds of mounds scattered over Tippah, Pontotoc, Lee, Itawamba, and Tishomingo counties. I am informed that there are several in Osctibbeha county, and perhaps it might be safely affirmed that they may be found in the greater part of the State.

The mounds are, so far as my observation extends, situated adjacent to water-courses. They are generally placed in what we call second bottoms—elevated level land lying between the bottom proper and the hills. Some, however, are in the low ground, near the water-courses. They are found on Tallahatchie, Oconitahatchie, Yorribie, Camp creek, Tishomingo, Twenty-mile creek, Manatachie, &c. Why they are always so situated I am unable even to conjecture. It certainly is not the result of chance.

The popular opinion among the people is that the mounds are places of burial. Human bones were found in one near J. M. Simpson's. A gentleman not far from here used the earth of a mound for making brick. He found, to use the expression of another, "a heap of coals and a piece of isinglass." In the mound near Sullivan's, ashes were found.

Another fact is, they are not confined to a particular locality, but are scattered through the country. Sometimes a solitary mound stands remote from others, and again you will sometimes find several grouped near each other.

I have no doubt that a thorough exploration of north Mississippi (and I might include the whole State perhaps) would show that mounds abound, and no field offers more abundant materials in which to search for the remains of a departed race.

While writing of these Indian mounds, allow me to direct your attention to

a fact which may or may not be of importance. Nearly 12 years ago I had pointed out to me on a long ridge, between John's creek and Friendship church, in Pontotoc county, the remains of ancient ditches or embankments. I did not examine them closely, and hence cannot describe them satisfactorily. The direction of the ditch or embankment could be clearly traced by the eye, and, according to my recollection, plots of ground in the shape of parallelograms were enclosed by these ditches. I was told that the first settlers found these things when they came to the country, and that the Indians did not know who had made them, or with what design. To me they seemed too regular and exact to be the work of ignorant savages. The idea suggested itself to my mind that perhaps these ditches or embankments were the remains of some fortified camp occupied by De Soto, during his famous march through this region of country. I believe that our histories relate that he spent a winter in camp in the Chickasaw nation. But my knowledge of the methods of fortification in vogue at that period is so limited that I am not qualified to venture an opinion on the subject. But the intelligent antiquarian might in these remains find a clue which would throw some light on the past, and interest the historic world.

All the accounts that I have seen of the wonderful march of this Spanish chieftain agree that he spent, in 1640, a cheerless winter among the Chickasaws, his progress being impeded by impassable rivers, &c. One historian says his camp was on the Yazoo, but this must be an error. It is generally conceded that he first reached the Mississippi near Memphis, and in marching from the Chickasaws to that point he would not see the Yazoo, which was in the Choctaw country. Some writer (perhaps Wailes, in his Geological Report of Mississippi, 1856) states that De Soto was in Pontotoc county. Now there is no stream between Pontotoc county and Memphis so likely to hinder his march as the Tallahatchie. Hence I think the cheerless winter he spent among the Chickasaws was on the south side of the Tallahatchie river. These remains are a few miles south of the river, and possibly this may be the very place where De Soto camped. If the locality remains uncleared, as when I saw it, I have no doubt they can still be traced. And should their examination be deemed of interest, I will with pleasure direct any one to the gentleman who pointed them out to me. An examination might demolish my theory, for you remember that I disclaim any knowledge of their character or extent. All that I can state positively about them is that they were there when the country was first settled by whites, and the Indians could give no information respecting them.

Captain B. F. Loughridge informs me that in 1852 the silver front of a cap, with the French inscription: "Dieu et mon Droit," was picked up on his place. This, probably, is a relic of the Bienville expedition against the Chickasaws, about 100 years ago. In the old Indian fields near Harrisburg, in this (Lee) county, cannon balls have been picked up, and other evidences of a battle found. They are probably relics of the same expedition.

CAVE IN CALAVERAS COUNTY, CALIFORNIA.

By J. D. Whitney.

The following is an account of the cave from which the skulls now in the Smithsonian collection were taken. It is near the Stanislaus river in Calaveras county, on a nameless creek about two miles from Abbey's ferry, on the road to Vallicito, at the house of Mr. Robinson. There were two or three persons with me who had been to the place before, and knew that the skulls in question were taken from it. Their visit was some 10 years ago, and since that the condition of things in the cave has greatly changed. Owing to some alteration in the

road, mining operations or some other cause which I could not ascertain, there has accumulated on the formerly clean stalagmitic floor of the cave a thickness of some 20 feet of surface earth that completely conceals the bottom, and which could not be removed without considerable expense. This cave is about 27 feet deep at the mouth, and 40 to 50 feet at the end, and perhaps 30 feet in diameter.

It is the general opinion of those who have noticed this cave and saw it years ago, that it was a burying place of the present Indians. Dr. Jones said he found remains of bows and arrows and charcoal with the skulls he obtained, and which were destroyed at the time the village of Murphys was burned. All the people spoke of the skulls as lying on the surface, and not as buried in the stalagmite. The skulls should be examined by some craniologist, and then if the results make it worth while to have excavations made in the cave to see if anything further can be discovered underneath the soil, $100 would pay the expenses, I presume. In the mean time everything will remain as it is. There can be no further harm done or material carried away.

I visited several other caves in this region, with negative results as far as bones were concerned.

[These skulls were, with a large number of others belonging to the Smithsonian Institution, examined by Prof. Jeffries Wyman, who discovered no peculiarities by which they could be distinguished from other crania of California. A complete series of measurements could not be made of their several dimensions without removing the stalagmite which encrusted nearly the whole surface of each.—J. H.]

ETHNOLOGICAL DEPARTMENT OF THE FRENCH EXPOSITION, 1867.

[Translated for the Smithsonian Institution from the *Revue des Cous Scientifiques de la France et de l'étranger.*]

M. G. de Mortillet is about to publish an octavo volume, having for its title "Pre-historic Rambles at the Universal Exposition," comprising a description of that part of the collections which illustrate our knowledge of the works of industry, as elaborated by our first ancestors, who were cotemporary with the great fossil animals; for scientific research has penetrated into that era, and is now seeking to restore to us their customs, mode of living, and, in fine, the first rudiments of civilization. Numerous figures are given representing the most curious objects to be found in this section of the Universal Exposition; indeed, the richest and most instructive ever assembled in one place. We borrow the following passage from this interesting work, exhibiting the most recent discoveries in pre-historic anthropology, and upon a subject which holds a place in the history of mankind analogous to that of geology to the history of the earth.

ART IN THE CAVES.

(First French corridor of the history of labor—first glass case from the centre.)

This case contains an exhibition of the state of art at the period of the reindeer, or the second cave epoch. There are 51 exceedingly curious pieces—a wonderful collection, which has been estimated at a million francs by an amateur, who made an offer of that sum if the whole should be transferred to him. Undoubtedly they are the most original works in the Exposition of 1867. Nothing similar has ever before been exhibited. Of very recent discovery, and only in part as yet seen by the public, they have never been brought together before

this time. It may further be stated that they are exclusively of French production, none such having as yet been met with elsewhere, and even for France are only at present found grouped in a small corner on the southwest part of the empire. One may almost say that in those obscure times a feeling for art had made its appearance, and was undergoing gradual development in a limited circle, without spreading among the adjacent tribes, possessed of similar manners and civilization. In fact, it is only made apparent at present by the representation of organic beings, by animals or plants, in Dordogne, (the principal centre,) Vienne, Charente, Tarni-et-Garonne, and at Ariego. The reindeer period with its various industry has, however, been recognized at many points in the eastern part of France. It has yielded a rich harvest in Belgium, where it has been studied with care by M. Edouard Dupont; finally it has been noticed in Wurtemberg, not far from Lake Constance, by M. Fraas, but neither of these stations have furnished representations of animals.

The substances in which the artists of that period worked are sometimes plates of stone, more or less schistose in character; likewise at times the ivory furnished by the defensive organs of the mammoth, or some portion of his bones; but the most common material was the horns of the reindeer, more than half of the objects on exhibition having been sculptured in it.

Of the 51 pieces on exhibition at least 12 of them belong to those staffs, pierced with one or more large holes at the base. The exceeding care taken in ornamenting these objects fully confirms the opinion of M. Lartet, who looks upon them as insignia of office or batons of command.

Six or seven other sculptured pieces belong to those implements so sharply pointed at the upper end and bevelled or sloped off at the base. This shows us that they were lance-points or heads, since they would never with so much pains have ornamented their arrows, which were to be lost at the first throw.

Upon some of these lance-points, as I have already stated concerning the second division, the slope of the base cuts away and destroys a part of the design. In certain instances of these batons of office, piercing the holes has produced the same effect. All this shows that these people placed art above industry. In truth, they were eminently disposed towards art. In their carving and sculptures there may be observed so true a feeling for form and movement that it is nearly always possible to pronounce exactly what animal is represented, and to perceive fully the intention of the artist. There is very considerable liveliness shown in the treatment, and, although only the infancy of art, real art it incontestably is. These efforts are far, very far removed from the clumsy, rough draughts made by children, and particularly the ridiculous counterfeits, caricatures.

The mammoth.—Standing before this case and fronting the centre, there is perceived a large plate of ivory, coming from Madeline, in Dordogne, (exhibited by MM. Lartet and Christy,) upon which is engraved, in a sketchy manner, an elephant with swelling forehead, very little eyes, and long trunk. What is still more interesting is that the tail of the animal is clothed with long hair forming an ample tuft or brush, which proves that the design is not to represent our living species, but that of the mammoth or long-haired elephant. Above it is the lower end of an official staff or baton of reindeer horn, carved into an elephant's head with protruding forehead, on either side of which may be seen a large ear and a small eye, and the trunk is neatly arranged extended along the base of the baton. This specimen, which belongs to M. Vibraye, comes from Langerie-Basse, in Dordogne.

Close at hand is a piece still more complete; it is an entire mammoth carved upon the broad antler of a reindeer. This specimen was found under the shelter of a rock at Bruniquel, (Tarne-et-Garonne,) and belongs to M. Peccadeau de l'Isle. The four limbs are at once recognized, straight, thick, without sensible joints, and terminated by large, flat feet. From the front passes out the haft of a poniard; if the broken stump which is left be taken away, it will be seen that

the animal has his head lowered, and the elongated trunk extends down to between the two front feet. The mouth is distinctly defined; the tusks only are not exactly in their right position, since, for their support, it was found necessary to lay them out against the blade of the poniard, causing them to be placed higher than they should be, and consequently locating the eyes in a somewhat abnormal relation. This elephant, so well characterized by his large, flat feet, his trunk and tusks, is certainly the mammoth. In fact, the sculptor has given an elevation or turning up to his tail, which having been broken off, as may easily be seen, the artist has drilled a hole from one side of the palmated antler to the other, and has inserted in the hole another similar caudal appendage. Existing elephants having but little or no hair, have no *fouet*, and do not turn the tail up. With the mammoth, however, it was far otherwise, having a felt thickly compounded of wool and hair. The elevation of the tail may also be noticed in the carved mammoth on an ivory tablet of M. Lartet. Very probably it was the accidental fracture of the tail of the mammoth which induced the artist of Bruniquel to arrange the tusks a little out of their normal position in order to give them a more solid support against the blade of the poniard.

The reindeer.—A curious, unfinished attempt to make a dagger of a horn of reindeer, coming to us from Langerie-Basse, exhibited by MM. Lartet and Christy, explains perfectly the preceding specimen. The handle is formed of a reindeer carved with his nose projecting towards the antlers flattened on his back, the front legs bent under his body so as not to wound the hand; the hind legs are stretched out so as to connect the animal forming the handle to the blade of the dagger, which is inserted in the posterior part.

This specimen is entire, but the carving is unfinished. This much cannot be said for two other poniard handles likewise representing the reindeer. They were also found under shelter of the rock at Bruniquel, as the mammoth just described; they belong to M. Peccadeau de l'Isle, and are of ivory. They are admirably sculptured, nicely finished, and executed altogether with much art. Undoubtedly this is superior to any specimen hitherto discovered. The two reindeer handles have the nose of the beast extended forward, a position into which it is forced by laying the antlers along the back. The blades of these daggers are broken. In one of them the blade passed out of the upper part of the body, and the hind legs were supported against it, the front legs being folded under the body. In the other, on the contrary, the blade passes out of the anterior part, from between the head and the fore legs. The hind legs, being projected beyond the body, unite again at a certain distance, leaving an open space between them, which in all probability answered the purpose of a ring, by means of which the poniard could be hung up. In the mammoth the space which was between the legs, closed at the feet, answered the same purpose.

Below these two handles for poniards will be found a flat piece of schistose rock, on which is engraved a sketch of an amorous combat of the reindeer. M. de Vibraye is the collector of this specimen, this true picture, at Langerie-Basse. A male animal is seen in fierce attitude, which, after having made his rival bite the dust, approaches the female in an amorous manner, of which nothing is seen but the hind quarter. This composition of quite a complicated character, rendered with a true feeling for the situation, is executed with remarkable sprightliness. Each of the animals is drawn as if none other was present. Thus the legs of the defeated reindeer, which ought to be concealed by the body of the female, are, notwithstanding, fully and neatly represented.

In one of the angles of this case many other carvings of the reindeer may be seen; among which one may be cited, a very handsomely sculptured head, from Langerie-Basse, belonging to M. de Vibraye, and a fragment of a staff of office, on which is carved a fawn of this deer with spotted skin, accompanied by its dam. This *morceau*, of the collection of MM. Lartet and Christy, comes from Madeline. For the sake of the locality mention may be made of a fragment of

a lance-head from the grotto of la Chaise, (Charente,) belonging to M. Bourgeois, on which are carved two reindeer.

Cave tiger.—The central line of this case is occupied, beginning at the left, by a fragment of a staff of office, from Bruniquel, (M. Brun,) on which is neatly carved a large tiger. Its head is rendered perfectly, and comparing it with a fine cranium found in this case, fronting the spectator, travée 4, one easily recognizes it as that extinct species which the people of Bruniquel intended to represent.

Man.—Above these objects are placed some representations relating to man. The principal one consists only of a fragment of an official staff, from Madeline, (MM. Lartet and Christy,) on which is engraved a small human figure of a thin and elongated shape, placed between two horse's heads, followed by a serpent, or a fish resembling an eel.

Next stands a small statuette in ivory, from Langerie-Basse, which has been designated by its owner, M. de Vibraye, as an obscene idol. It is a female figure, thin and elongated, the sexual parts being very large, and the posteriors also prominent. The head and feet are wanting, having been broken off in ancient times; the arms never existed. A little on one side may be seen a piece of a lance-head from Madeline, (MM. Lartet and Christy,) on which are carved in bas relief, one after the other, a row of hands, so shaped as to exhibit but four fingers. M. Lartet has called attention to the fact that certain savage tribes still represent the hand in this manner, omitting the thumb.

The ape.—Adjoining these human effigies is a small plate of bone from Bruniquel, (M. Peccadeau de l'Isle,) on which is carved the head of an animal closely resembling that of an ape. No fossil bones of this animal have as yet, however, been discovered.

The great bear.—At the end of the central line, right side, is a schistose pebble, having on a flat surface a sketch of a great cave bear. This design, discovered in the grotto of Massai (Ariege) by M. Garrigou, can only be seen with difficulty. At the time of its discovery the depressed tracings were partly filled by incrustations which served to render it more plainly visible, but having passed through numerous hands, by which means the surface was more or less rubbed, these incrustations have at length nearly disappeared, rendering the sketch but feebly visible.

Stag.—Next to the pebble of Massai comes a piece of stag-horn from Madeline, (MM. Lartet and Christy,) on which is carved an ordinary stag.

The aurochs.—In one of the corners are grouped different representations of this bull. Among others a head carved on a reindeer horn, being the lower end of a baton of office, from Langerie-Basse, belonging to M. de Vibraye. Other heads carved in the same material or on bone exhibit handsome types of bulls, which should be referred to the aurochs. One is particularly remarkable, from Langerie-Basse, and belonging to M. de Vibraye. From Eyzies, also, (MM. Lartet and Christy,) there is a young bull carved with great perfection.

Horses.—In another corner the representations of horses are grouped together. On a staff of office of reindeer horn from Madeline, (MM. Lartet and Christy,) may be viewed a carving of three horses in a manner perfectly characteristic of the animal.

A very singular implement, made of reindeer horn, from Langerie-Basse, (MM. Lartet and Christy,) which is armed at one end with a harpoon carrying a barb, shows very near to this latter appendage a finely carved horse's head. The ears are carefully elaborated—a little long. If we connect this fact with what is shown in the carving of a head in this third travée, the ears of which resemble those of an ass, we will be led to believe that at that epoch there existed a race of long-eared horses.

There is yet to be noticed a number of different animals scattered through this case, but more particularly grouped in the fourth corner, viz:

The wild goat.—Representations of these animals are brought from Madeline

and Langerie-Basse, (MM. Lartet and Christy,) and from Massai, (Ariege,) (M. Garigou.) Those which are best executed are from Langerie-Basse, on a large palmated surface of reindeer horn.

Birds.—Some figures of birds having a long neck, from Madeline and Langerie-Basse, (M. de Vibraye,) very much resemble the swan. On a piece of a lance-head from Madeline (MM. Lartet and Christy) may be seen a series of birds, one following the other, probably geese.

Fishes.—There may be seen a figure of a fish on the harpoon previously described as bearing a horse's head. A fragment of reindeer horn from Madeline (MM. Lartet and Christy) contains three or four fishes with their scales distinctly marked, even exaggerated; and another skeletonized, as it were, finely carved on a piece of the lower jaw of a reindeer; it comes from Langerie-Basse, (M. de Vibraye.) Another, exhibited by M. Garrigou, brought from La Vache, (Ariege,) is finely carved on a piece of bone; it is thought to be a figure of the morse. But the appendages regarded by some as representing the tusks of that animal, seem to me to be nothing more than the beard of the barbel, gudgeon, or loach, fishes common in that region.

Reptiles.—Figures of different reptiles more or less distinct are exposed; one of a tadpole is very neatly sketched on a lance-point, which comes from Madeline, (MM. Lartet and Christy.)

Flowers.—The vegetable kingdom is infinitely less represented than the animal. Among all the figures here recounted as filling the central glass case, there are found sketches of but three flowers. Two of these are large, having nine petals, carved upon a lance-point, from Madeline, (MM. Lartet and Christy;) and one of the shape of a tulip with a waving stem, also carved on a lance-point from Langerie-Basse, (M. de Vibraye.)

Conclusion.—The contemporaneity of man and the various extinct animals, and with the indigenous reindeer in France, is broadly, firmly, incontestably proven by the discovery of these products of human industry and skill, so abundantly mingled with the exuvia of these extinct or emigrated animals, in the undisturbed quarternary beds, and in the midst of cave deposits which have never been manipulated. In this relation an inspection of the glass cases which decorate the left part of the first corridor of the history of French labor, leaves no doubt on the mind; they fully convince the most obstinate and incredulous.

The case containing an exposition of the art of the reindeer period affords a demonstration still more irresistible. Man has not only perfectly represented the reindeer, an animal now emigrated to the north, but likewise the great cave bear, the cave tiger, the mammoth, which are extinct, and habitually the carvings are executed on the spoils of the reindeer and mammoth themselves. Beyond all question man was the contemporary of those animals, parts of which he used for his sustenance, and which he has represented so truly by his art. No more convincing demonstration could be desired or expected.

NOTES ON INDIAN HISTORY, &c.

BY DR. F. V. HAYDEN, U. S. GEOLOGIST.

JULESBURG, COLORADO TERRITORY, *October* 10, 1867.

I have made some interesting observations in regard to Indian history in the course of my geological survey of this Territory. Most of the Indians of the lower Missouri, as the Pawnees, Otoes, Iowas, Missourias, live in earth-built or stationary villages, and have done so from time immemorial. The tribes on the upper Missouri do the same—Arickarees, Mandans, and Minnetáns. All along the Missouri, in the valley of the Little Blue, Big Blue, Platte, Loup Fork rivers I have observed the remains of these old dirt villages, and pieces of pottery are almost invariably found with them.

But on a recent visit to the Pawnee reservation on Loup Fork I discovered the remains of an old Pawnee village, apparently of greater antiquity than the others, and the only one about which any stone implements have as yet been found.. On and around the site of every cabin of this village I found an abundance of broken arrow-heads, chipped flints, some of which must have been brought from a great distance, and a variety of small stones, which had been used as hammers, chissels, &c. I have gathered about half a bushel of the fragments of pottery, arrow-heads, and chipped flints, some of which I hope to place in the museum of the Smithsonian next winter. No Pawnee Indian now living knows of the time when this village was inhabited. Thirty years ago an old chief told a missionary that his tribe dwelt there before his birth, but he knew nothing of the use of the stone arrowheads, though, he said, his people used them before the introduction of iron.

This discovery is interesting, as it is the first tribe that I have ever been able to find connecting the stone age with the persons in the Missouri valley. I have asked the most intelligent Indians of more than 20 tribes in the valley how far back in the past the Indians used stone arrow points, and I have received but one answer. They would point toward heaven and say, "The Great Spirit only knows. We do not."

At Pine Bluffs, on Cole creek, a branch of the Platte, and on the line of the Union Pacific railroad, there are large quantities of chipped flints and arrow-heads, showing that in former times they wrought them at this locality.

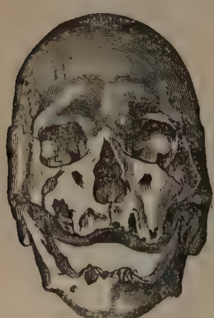
Mr. S. B. Reed, superintendent of construction Union Pacific railroad, found specimens of pottery abundant, arrow points, and chipped flints on the plains near the Humboldt mountains.

The pottery was made of disintegrated granite, as it was full of particles of mica. These remains may possibly be modern, for the Digger Indians, who inhabit this region, a low, degraded people, even now use flint arrow points, though they use no pottery. There is now no evidence that the Indians of this region ever used any pottery like that found, so that it may be possessed of some antiquity.

I have collected considerable material in the Omaha, Pawnee, Winnebago, and Otoe languages for the second part of ethnography and philology of the Indian tribes of the Missouri valley, and hope to have the memoir ready for publication in two years.

DESCRIPTION OF A HUMAN SKULL IN THE COLLECTION OF THE SMITHSONIAN INSTITUTION.

By J. Aitken Meigs, M. D.



This remarkable cranium, No. 6439 of the Smithsonian collection, was found in June, 1866, in a fissure of the rock, at Rock Bluff, on the Illinois river,

where this river is crossed by the 40th parallel of latitude. The fissure, which is three feet wide, was filled with the drift material of this region, consisting of clay, sand, and broken stone, the whole being covered with a stratum of surface soil. In this bed. which had apparently been undisturbed since the deposit, was found the skull under consideration, at the depth of three feet.

It is dolichocephalic and symmetrically oval in form, and is especially remarkable for its great length, for the protuberance of the posterior or parieto-occipital region, the flatness of the frontal bone, the great development of the superciliary ridges and the mastoid processes, and the depth of the temporal fossæ. The length as compared with the breadth is as 41 to 27, and with the height as 41 to 28. The sagittal suture has evidently undergone complete ossification at a comparatively early period; a small portion only of the anterior part of this suture showing any traces of the serrations. The lambdoidal suture appears to have become ossified at a later period, and is less completely obliterated than the sagittal. The occipito-temporal sutures, which are generally the first to ossify, are still open, as is also the coronal suture. Owing to this departure from the usual order of ossification of the sutures, the lateral expansion of the brain has been interfered with, and its antero-posterior or longitudinal development greatly favored. The extreme elongation of the skull, therefore, is readily accounted for. From the superior region the skull widens out towards the base to such an extent that the intermastoid diameter or breadth at the base is somewhat greater than either the bi-temporal or vertical diameters. The mastoid processes are very large. The upper half of the os occipitis is quite prominent, and the convexities indicating the position of the cerebellar fossæ moderately full and rounded. The alisphenoids curve backwards considerably between the anterior, inferior angles of the parietals and the squamous edge of the temporal bones. Their external surface is deeply concave, as is also that portion of the os frontis lying directly behind the external angular process, and below the temporal ridge. Hence the temporal fossæ are unusually deep. The superciliary ridges are thick and protuberant, curving somewhat like the horns of a goat, upwards and outwards from the glabella, of which they appear to be the continuation, and completely overhanging the ossa nasi and the upper and internal angles of the orbits in such a manner as to coalesce with and obliterate the inner half of the supra-orbital margins. Above these ridges the os frontis is incurvated, but becomes somewhat more prominent again at a point just below the middle of the frontal suture. The great prominence of the superciliary ridges in this cranium is a notable feature, inasmuch as the American aboriginal skull is characterized by the absence, rather than by the presence of these ridges. I find, upon careful examination, that in the great majority of the American Indian crania contained in the collection of the Academy of Natural Sciences, these ridges are wholly or almost entirely absent. They are moderately developed in the following specimens: Assinaboin, No. 659; Naas, No. 213; Klikatats, Nos. 203, 207, 461; Calapooyah, No. 574; Cherokees, Nos. 1285, 1297; Chetimache, No. 70; Chippewa, No. 683; Creeks, Nos. 441, 579, 1454, 204; Hurons, Nos. 1217, 1218; Iroquois, Nos. 16, 989; Lenapés, Nos. 418, 1265; Mandans, Nos. 740, 741, 742, 1220, 1222; Miami, No. 106; Mohawks, Nos. 895, 896; Narragansetts, Nos. 950, 954, 956, 1040; Naticks, Nos. 110, 116; Osage, No. 54; Ottigamie, No. 415; Penobscot, No. 89; Pottawatomie, No. 737; Seminole, No. 732; Shoshoné, No. 1449; Euchee, No. 39; Oneida, No. 33; Pocasset, No. 1036; Seneca, No. 1516; from the mounds, Nos. 53, 1270, 1511; Inaya, No. 990; Araucanians, Nos. 655, 997, 1242; Caribs, Nos. 638, 692; Brazilians, Nos. 1254, 1528; Peruvians, Nos. 67, 1279, 1282, 1363, 13, 77, 84, 85, 92, 409, 1456, 1461, 1462, 1465, 1470, 1472, 1473, 1481, 1482, 1499, 1500, 1504, 72, 996, 1413, 1416, 1417, 1426, 1427, 1432, 1440, 1442, 73, 449, 68, 91; Kahnica Mexican, No. 34; Otomie Mexicans, Nos. 1000, 1002; Pames Mexican, No. 681; Ancient Mexicans, Nos. 1314, 682, 234; Lipans, Nos. 1345, 1346; Modern Mexicans, Nos. 1515, 555, 558.

The superciliary ridges are more decidedly developed in the Lenapés, Nos. 135, 249; Mandans, Nos. 78, 563; Miami, No. 541; Mimetari, No. 749; Otoes, Nos. 755, 756, 757; Ottawa, No. 1006; Ottigamie, Nos. 639, 694; Pottawatomie, No. 657; Sauks, Nos. 561, 1246; Shawnees, Nos. 691, 1210; Shoshonés, Nos. 1446, 1447, 1448; Upsarookas, Nos. 1228, 1229; Winnebagoes, Nos. 559, 560; Yamassees, Nos. 1215, 1216; Apache, No. 935; from the mounds and caves, Nos. 416, 1237, 1510, 436, 43-, 653, 439, 440, 1287, 1288, 992, 1564, 1512; Kenawha, No. 212; Brazilian, No. 1529; Peruvians, Nos. 1365, 1366, 1367, 1368, 75, 95, 406, 697, 752, 1474, 1475, 1490, 1491, 1495, 1496, 1501, 1509, 1221, 1326, 1370, 1373, 1407, 1408, 1428, 1443, 1484, 412, 414, 452, 231; Mexicans, Nos. 714, 717, 718, 720.

The dimensions of the Smithsonian skull are exhibited in the following table:

	Inches.
Occipito-frontal or longitudinal diameter	$7\frac{11}{16}$
Frontal diameter	$3\frac{3}{8}$
Bi-temporal diameter	$5\frac{1}{16}$
Bi-parietal diameter	5
Posterior transverse diameter, (between the posterior, inferior angles of the parietalia)	$5\frac{3}{8}$
Vertical diameter	$5\frac{1}{4}$
Intermastoid diameter	$5\frac{3}{8}$
Occipito-frontal arch	$14\frac{5}{8}$
Frontal arch	$11\frac{1}{8}$
Parietal arch	12
Occipital arch	10
Horizontal periphery	$20\frac{3}{4}$
Meato-frontal diameter	$4\frac{1}{16}$
Meato-parietal diameter	$3\frac{1}{16}$
Meato-occipital diameter	$4\frac{11}{16}$

The region of country from which this cranium was obtained was occupied, when first visited by the Jesuit missionaries in 1665, by the Sauks, Saukies, or White Clay Indians; the Foxes, Ontagamies, or Ottigamies, or, as they called themselves, Musquakkink, or Red Clay Indians; the Kickapoos, and the Illinois—the latter comprising the Kaskaskias, Cahokias, Tamaronas, Peorias, and, by confederation, though not by consanguinity, the Mitchigamias. These western tribes of the great Algonkin stock are represented in the academy's collection by three Sauk, four Ottigamie, and six Illinois crania. The Smithsonian cranium bears no resemblance to the Sauk or Ottigamie skulls, nor to any of the Illinois crania, except Nos. 1500 and 1511, which were taken from an ancient mound. These two skulls are very much alike, and they resemble the Smithsonian head in their oval form, in the flatness of the frontal bone, the prominence of the superciliary ridges, and the depression above these ridges. There are two other mound skulls in the academy's collection, Nos. 1287 and 1288, which bear some resemblance to the skull under notice. These were taken from an ancient mound in Chillicothe, Ohio, by Dr. E. H. Davis and Mr. E. G. Squier. No. 1287 has a flat forehead and somewhat elevated superciliary ridges, and is dolichocephalic and oval in form. No. 1288 is more like the Smithsonian specimen in its elongated and oval eorm, and in the prominence of the occiput; though the frontal bone is not so recedent, and the superciliary ridges much less prominent. The dolichocephalic Upsaroka skull, No. 1228, somewhat resembles the Smithsonian specimen in the elevation of the superciliary ridges, and the flatness of the frontal bone. Of all the American Indian crania, however, contained in the museum of the academy, No. 744, which I have provisionally referred to the Kootenays, approximates the Smithsonian specimen most closely in its dolichocephalic, oval form, the flatness of the forehead and prominence of the

superciliary ridges. No. 744, however, is less regularly and symmetrically oval, projects more in the super-ccipital region, and has a more recedent forehead. The superciliary ridges are equally prominent in both skulls, but in the Kootenay head they do not coalesce with the supra-orbital margins, as is the case in the Smithsonian skull. In the Kootenay cranium the supra-orbital margins are distinct and well defined throughout their whole course, from the internal to the external angular processes. In the Smithsonian head, as we have just seen, the inner half of these margins are so encroached upon by the superciliary ridges as to be obliterated.

Bearing in mind the locality in which it was found, the skull under consideration is so far unique in its ethnical character, that I do not feel authorized to refer it to any of the aboriginal American cranial forms with which I am acquainted. If the position in which it was discovered be any evidence of its age, it belongs, in all probability, to an earlier inhabitant of the American continent than the present race of Indians. In the absence of a complete series of American Indian crania, it is impossible to assign to this skull its proper ethnical position.

INTRODUCTION TO THE STUDY OF THE COPTIC LANGUAGE.

By M. Kabis.

[*From the Transactions of the Egyptian Institute.*]

The Egyptians, when they adopted Christianity, substituted Greek letters for the ancient hieroglyphics, and after that time used the language which the moderns designate as the Coptic, which prevailed over Upper and Lower Egypt until the Arabic language, introduced with Mahomedanism, took its place. We shall, further on, speak of the true etymology of the word Copt; but it will not be out of the way here to show what were the motives and the historical circumstances which led the Christians of Egypt to make this change.

We have to remark, then, that the graphic system of the ancient Egyptians was so intimately connected with their religious system that it was scarcely possible for one of them in the time of the Pharaohs or of the Ptolemies to write the smallest circumstance without mixing it up with the symbols of mythology and of polytheism. The images of the gods and of the sacred animals formed many of the characters employed in their writing; and an Egyptian could no more avoid using them than we could write without our alphabet. Now, nothing could be more at variance with the purity of the Christain religion, then newly adopted by the Copts, and the piety of the worshipper than the profane hieroglyphic symbols. The early Christians of Egypt then found it to be absurd to represent under the images of Ammon, or Ptah, or Osiris, the God of their faith, whom they reverenced as a pure Spirit, separate from every sensible or material form. Wishing, then, to disengage themselves as much as possible from the ancient superstition, these disciples of St. Mark rejected the graphic system of their ancestors, supplying its place with the Greek alphabet, to which they added six purely Egyptian letters, to express sounds in their language, which could not be represented by the Greek.

With the alphabet they also adopted a number of Greek words. That was in the beginning a matter of necessity. They were not willing to express in the equivocal terms of the ancient mythology the new ideas of Christianity. But this necessity soon degenerated into an abuse, and Greek expressions became the fashion. This was much more the case in Lower Egypt, on account of the frequent intercourse between the Greeks of Alexandria and the inhabitants of the delta, and for the same reason the dialect of Memphis is less pure than that of Thebes. It must be remarked, also, that the introduced Greek

words underwent no change from their original form. They may be recognized at a glance, and do not in anywise alter the face of the Coptic language. This is a simple and positive evidence that the language and literature of the Copts are essentially Christian. Such manuscripts as have been published, or up to this time examined by savants, prove that the language was cultivated only by the monks, who during the early ages of Christianity dwelt in the deserts of Egypt. These holy anchorites concerned themselves only with the exercises of devotion. Abandoned to themselves, and separated from any intercourse with the world, they divided their time between prayers, manual labor, reading the Bible and the lives of other monks. The study of literature, science, history, especially if it were pagan, had no interest for them. Their writing, then, could treat only of religion and monkish institutions. I believe it would be difficult to find among Coptic manuscripts any proper scientific compositions. The Coptic language should not, however, lose its interest with savants. If the anchorites of the Thebaid did not treat *ex professo* of historical events, their writings could, notwithstanding, furnish many historical data of precious value, and illustrate many points which now embarrass the critic. For it is well known that, since the time of Constantine, the history of Christianity and the church is intimately connected with that of the people and the empire. The bishops often shaped the decrees of the Cæsars, and the latter charged themselves with executing the ordinances of the Pontiffs. The Coptic monks, then, when treating of the history of the church, can supply us with interesting documents relating to the history of their age. They also occupied themselves frequently in translating the works of the more celebrated Greek fathers, and we might find interesting treatises preserved in Coptic, of which the original Greek no longer exists. I have myself seen such fragments in the library of the Vatican at Rome, and executed a translation of them into Latin for the venerable Cardinal Mai, curator of that library. These are, however, not the only motives to interest us in the Coptic; it has for us and all the learned world a very special and supreme importance. The immortal Champollion the younger, when seriously applying himself to study the famous inscription on the stone found at Rosetta, during the French expedition in Egypt, succeeded, in 1822, in deciphering the hieroglyphic symbols. The interest excited in Europe by that discovery is known to all, and the learned of all nations since have occupied themselves in perfecting this growing science. Now all the learned, as well as Champollion the elder, have acknowledged that the Coptic language is no other than that of the ancient Egyptian Pharaohs; that it is the key and the dictionary of hieroglyphics; that without an available knowledge of it it would be very difficult or well-nigh impossible to interpret them.

There would be a truly valuable service rendered to science if those who are in position to do so would suggest to his highness the Viceroy Mahomet-Said to assemble at the museum or at the Egyptian Institute, both of which do him so much honor, a collection of Coptic manuscripts, which should be accessible to students and the learned. In the Coptic convents there lie, enveloped in dust, innumerable Coptic volumes; no one there understands them, and the worms only have the privilege of visiting, gnawing, and destroying them. To this class of MSS. should be added a collection of Arabic authors, particularly of the middle ages, which was the golden period for Arabic literature. * * *

If I have one wish which I should like to see reciprocated in the breasts of this assembly, it is that my colleagues should unite their efforts with mine to aid in restoring the Coptic language to life here in its own native place. Our society will fail in its mission if it shall neglect this duty. The Institute will no longer be Egyptian if it fail to occupy itself with the language of Egypt. Besides, all the learned societies of Europe are impatient to see the results of our labors upon ancient Egypt. Behold, then, how much is expected of this Institute!

NOTES ON THE "TONTO" APACHES.

BY CHARLES SMART, BREVET CAPTAIN AND ASSISTANT SURGEON U. S. ARMY, FORT M'DOWELL, ARIZONA.

[A partial vocabulary of the language accompanied the original, which will appear elsewhere.]

THEY form a village or sub-tribe of the people known as Apaches. They call themselves "Coyateros;" Americans and Mexicans call them "Tontos," applying the name "Coyatero Apaches" to a tribe dwelling in the mountains southeast of this, beyond the Gila river.

About a year ago, that is previous to the arrival of the United States troops in this part of the Territory of Arizona, these Indians dwelt in the neighborhood of what is now the site of Fort McDowell, on the banks of the Verde or San Francisco river, a few miles above its junction with the Salinas, Rio Salado, or Salt river. The Verde at this point runs southward through a valley about twenty miles broad, which is bounded on the east by the Mazatsal range of mountains, and on the west by a chain of hills to which no name has been applied. The bottom lands are very narrow, not more than a half a mile broad at their broadest part. The soil is sandy, but when irrigated is very fertile, yielding large returns of corn, sorghum, beans, melons, &c. Cottonwood trees, willows, and alder, line the banks in great luxuriance, and grape, melon, and hop vines bind the whole, often into an impenetrable thicket.

From these low lands, extending outwards and gradually rising to the foot-hills of the mountain ranges, is a dry rocky "mesa" very irregular in surface, from the numberless deep "arroyos" which the autumn rains have washed out. The "mesa" is more or less completely covered with sage brush, mesquite, pálo verde, and a variety of individuals of the cactus family. Towards the mountains grows the mescal, much used by the Indians as an article of food. During the rainy months, July, August, and September, a light covering of grass spreads over it, but throughout the greater part of the year it is bare and garish—rocky on the ridges, sandy in the arroyos.

On the Mesa, more especially towards the mountains, deer are occasionally met. Cayotes and rabbits are plentiful, of the latter two kinds—the cotton-tail and Jackson rabbit; rats, gophers, and other rodents are equally numerous. Of birds, quail exist in great abundance. Here the Indians say they were born and grew up, living upon deer, rabbits, rats, mescal, mesquite beans, cactus fruits, and a variety of nuts gathered on the mountains. They were at constant war with the Pininos, and made occasional plundering excursions to Sonora, but on the establishment of Fort McDowell they retired to the eastern mountains, taking up their abode in the cañons to the north and east of the Mazatsal peaks. Of late their rancheria has so often been broken into by scouting parties of the friendly Indians, that they do not seem to have established a permanent settlement. But the permanent differs in nothing from the temporary hut, both being simply a brush shanty, with a hole scooped in its floor by way of bed-room.

In this sub-tribe, during the time it remained at the fort, I counted a hundred and fifty warriors and forty women and children, but the majority of the women and children, and probably a proportion of the warriors, did not leave the mountains. They gave us to understand that there was sickness among the people in the hills. They stated that there were other villages of their people whom

they expected to arrive at the fort for the purpose of making peace, and that together they numbered about two thousand (2,000.)

Their average height is about five feet four or five inches. They are slimly built, and possess but little muscular development, yet they are very agile, climbing the mountains with great rapidity, and running on more level ground for many miles without any semblance of fatigue. The skin is of a light brownish red color, so fair in many instances as to lead to the probably correct supposition that Spanish blood has been mixed with the Indian stock. The features present nothing peculiar. They have generally the traits well marked of the American Indian; some, however, have a full round face and Chinese cast of countenance. The head is covered with a mass of rusty black hair, cut off in front on a level with the eye-brows, and permitted to grow a little longer behind, but never reaching the shoulders; occasionally the hair is worn quite short, round head cut. The beard, when any does grow, is dragged out hair by hair, by means of an elongated piece of tin, formed into a forceps by being bent lengthwise on itself, and which is usually carried suspended from the neck by a thong of buckskin.

They practice no such disfigurement as flattening the head, but among the women were observed a few who had had the cartilaginous portion of the nose cut off, thereby spoiling their good looks, for it was noticeable that only those who had any pretensions to beauty had been so mutilated.

A scrofulous taint affects their system; this was more distinctly manifested among the children; but of the adults many were suffering from strumous ophthalmia or its consequences.

The dysentery, which at the time was severe on the troops stationed at the fort, did not exempt the Indians from its attacks. One died from this disease during their stay here, and many were said to be sick in the mountains.

With one exception they were not painted. The paint in the exceptional case was of a grayish white color, and laid on in lines, narrow, closely set, and wavy, transverse and parallel, covering the face, chest, and back. Their dress consists of the breech-cloth and a pair of buckskin moccasins. The latter have a stout hard sole, which curves upwards a little in front of the toes; poorer specimens only cover the ankles, but others are so long that when drawn up they encase the thighs. This, with a leather bracelet on one wrist and a bow and quiver of arrows, forms the general outfit. But others are more completely equipped, wearing a buckskin thrown over one shoulder and fastened in the opposite armpit, and perhaps possessing a waist-belt of leather and an old sheath-knife, the product probably of some Sonora enterprise.

Some of them carried a straight stick about five feet long, curved into a hook at one end, like the handle of a walking-stick. This they call kish-ish-ai, and use it in hooking down the fruit leguara and in tearing up the earth when breaking into a rat or rabbit hole. They possessed also about half a dozen lances, formed of a long knife or bayonet socketed into the end of a long pole. The bow is a stout piece of tough wood obtained from a tree stated by those who have seen it to bear some resemblance to the mulberry. It is about five feet long, strengthened at points by a wrapping of sinew. It is straight along the greater part of its length, but curves lightly towards its extremities, which are joined by a sinew string stranded and rolled into a perfect round. Their arrows from notch to point are three feet long. They are formed of a cane which grows in the mountains in the neighborhood of springs and water-courses. For a distance of six or seven inches from the notch the cane is winged with four strips of feather, held in place by threads of sinew. Into the hollow of its other extremity is inserted a slender piece of stiff wood, which is colored, as if with the blood of some animal, and which bears on its free end an elongated triangular piece of quartz, flint, or rarely iron. This arrow-head is sharp at the point and slightly serrated along the margin. In some the slender cylinder of

wood bearing the arrow-head is inserted firmly into the cane and withed in that position, while in the others the attachment between the two is so slight as to admit of being severed by very gentle traction. None wore any covering for the head with the exception of the chief, whose crown consisted of a closely fitting skull-cap of skin, unadorned behind, but covered in front with feathers and many spangles of brass and tin. He also possessed a doublet of prepared buckskin, brownish red in color, with some blue linen markings on it. They were very eager to obtain cast-off clothing from the troops; and their requests for tobacco were constant. The latter they manufactured into cigaritas, although they had no objection to a pipe when offered.

The only methods of communication between distant parts of the country (excluding the messenger of course) which I knew them to employ are fire by night and smokes during the daytime.

I saw no earthenware vessels among them; the utensils employed in the preparation of food being shallow basins of closely netted straw. They carried water in pitchers of the same material, but they were matted all over with a pitch, which communicated its flavor to the contents.

They are not bold in their manner of carrying on a war, attacking only when their numbers, and a well-laid ambush, promise a certainty of success. They seldom scalp, but very frequently mutilate otherwise the bodies of their slain enemies.

In disposition they seem to be light-hearted, but subject to sudden fits of suspicion and timidity, which is perhaps sufficiently accounted for by the active campaign of late kept up against them by our Indian allies, and the circumstance of living for the first time in the neighborhood, and in a great measure in the power, of the whites. Very frequently after having spent the evening in dance and song, during the night they would become suspicious of something and take to the mountains, returning only after some days, and in small parties at a time. The dance is similar to that of the California Indians; a stamp around, with clapping of hands and slapping of thighs in time to a drawl of monotones.

The only act of a religious character which I observed, took place during our first interview with them. The old squaw, who was the first to venture into the fort, intimated, through a Maricopa who possessed a smattering of Apache, that her people wanted peace, but being afraid to come among the whites, prayed them to come to the mountains to hold a council. Some four or five officers accompanied her. Shortly after crossing the river they were met by a small party of the Indians, one of whom chalked a cross on the breast of each, with a yellow earth, which he carried in a satchel at his belt. Previous to doing so he muttered some words very solemnly with his hand uplifted and eyes thrown upwards. Again, on arriving at the camp of the people, the chief and others in greeting them took a similar vow, touching thereafter the yellow chalked cross. Sonora may have furnished them with some of their notions of a Deity.

The peace negotiations fell to the ground, inasmuch as the other villages of the tribe, not having been so great sufferers from the war as this one, refused to join it in its propositions.

CHARLES SMART,
Brevet Captain and Assistant Surgeon U. S. Army.

FORT McDOWELL, ARIZONA,
September 13, 1866.

REPORT OF EXPLORATIONS IN CENTRAL AMERICA.

By Dr. C. H. Berendt.

New York, *December* 24, 1867.

Although my labors in exploring the northern part of Guatemala and southeastern Mexico are not finished, and though I intend to return to the work after a short visit to the United States, I deem it my duty to lay before you a report of the results which have thus far been obtained under the auspices of the Smithsonian Institution.

Having occupied myself in former travels and during several years of residence in Tabasco with researches relative to the geographical and ethnological features of this almost unknown part of America, I resolved to complete my observations by a visit to the belt extending from the Caribbean sea through Belize, Peten, and Chiapas to the Pacific ocean. This region, scarcely ever visited by modern travellers, presents objects of high interest in all branches of ethnology and natural history as an important centre of ancient civilization and a region abounding in the productions of both the vegetable and animal kingdoms. The Institution furnished the instruments for meteorological observations and part of the outfit required for collecting specimens of natural history. It also procured letters of recommendation from the diplomatic agents of England, Guatemala and Honduras to the governments and local authorities of the different districts to be visited, and secured the co-operation of several learned societies and private gentlemen interested in pursuits of this character, in contributing to the expenses of the expedition, with a view to obtain a share of the specimens collected.

I left the United States in the bark Pallas the 2d day of December, 1865, and arrived in Belize the 21st of the same month. My letters of introduction procured me a very friendly reception from the governor of the colony. He introduced me to all the prominent officials and leading merchants, from whom I could obtain the necessary information as to topography and resources of the country, and in particular of that almost uninhabited region through which I had to pass on my way to Peten. The crown engineer, Mr. Faber, and two civil engineers kindly communicated to me what they knew relative to the regions which had been surveyed or visited by them, and I was permitted to copy a number of ancient and modern manuscript maps of the colony. With the chief magistrate of the police court, Judge S. Cockburn, a member and meteorological correspondent of the Royal Astronomical Society of London, I arranged cotemporaneous observations for the purpose of computing with more accuracy the absolute height of the principal points included in my tour. I found in the possession of Mr. Parson, an American merchant, a valuable collection of specimens of natural history, and was so fortunate as to secure it for the Smithsonian previous to the death of Mr. Parson, which took place a few months afterwards. I also made a very agreeable and useful acquaintance in the person of the Rev. Alexander Henderson, a distinguished linguist,* whom I found

* The Rev. A. Henderson, Baptist missionary in Belize since the year 1834, has written a grammar of the Moskito language, printed in New York in 1846; a Gospel by Luke and a vocabulary, MSS.; the Gospel according to Matthew, in the Caribbean language of Honduras, printed Edinburgh, 1847; a grammar and enlarged vocabulary of the same, MSS., since 1855 in the hands of the Ethnological Society, London; a translation into English of Beltran's *Arte de el Idioma Maya;* a translation into Maya of the book of Genesis and the book of Psalms, MSS.; a Maya primer, printed in Birmingham, 1863, and two tracts in the same language, published by the American Tract Society.

occupied with a dictionary of the Maya language, giving the dialect actually spoken in the district of Bacalar, Yucatan, and in some recent settlements of Yucatan Indians in the territory of the colony. Having been engaged myself for a number of years in the work of reproducing from old and rare manuscripts the Maya language as spoken and written in the sixteenth and seventeenth centuries, I derived both information and pleasure from the intercourse with this learned missionary. The collections of specimens of natural history made in and near Belize consisted almost exclusively of birds, shot and prepared by my assistant, and have been forwarded to the Smithsonian Institution. Unfortunately circumstances beyond my control obliged me to part in Belize with this assistant, very much to my regret, as his dexterity and expediency in skinning and preserving specimens would have added a far greater value to the collections subsequently made. Another unlucky accident was the loss of a trunk containing a number of instruments belonging to the Institution and myself, and several articles of travelling apparel, stolen from the loaded boat in the night before my intended departure from Belize, during a temporary absence of the watchman. Part of the most necessary implements was within a few months kindly replaced by the Institution.

After having lost a few days in fruitless endeavors to recover the stolen property, of which no traces have as yet been found, I left Belize the 12th of January, 1866, pursuing the course of the Belize river upwards as far as it is navigable for larger canoes, and reached, after eleven travelling and two resting days, San Pedro Buenavista, the farm of a mestizo from Yucatan, on the western branch of the Belize river, a few miles above its confluence with the southern branch, or Rio Macal. The Belize river has its head-waters in the wide plains limited to the north by the Chaltuná, or Peten lake, and to the south by the Passion river, (Rio de la Pasion.) The country through which it winds to the coast is alluvial, with sandy tracts between the tributary rivers and the main channel called pine ridges. Specimens were collected from three species of pines and of two oaks, which are almost the solitary vegetable production of these sandy plains; and also, among a few other birds, a woodpecker which, like the *Melanerpes Formicivorus*, in California, preserves acorns in neat round excavations pecked into the soft barks of the pines. This is for the purpose of feeding on the worms which soon appear within the nuts, leaving the trunks of the pine trees perforated with many holes resembling those produced by musket balls. Rocky ridges of a calcareous stone intersect now and then the course of the river, causing a number of rapids, of which, in time of high water, the passage is rather dangerous. Little could be done during the boat voyage besides a careful rectification of the river's course in the maps, and the entering in their proper places of names of existing settlements along the river banks. While on the Rio Hondo and Rio Nuevo, as well as on the coast of the British colony, a number of well-conducted agricultural settlements exist, there are on the Belize river only wood-cutting establishments belonging to merchants in Belize. These are either being actually worked under the direction of a foreman, (usually a mulatto,) or abandoned, the buildings being occupied by negroes, who make a scanty living cutting logwood on their own account, which they sell in Belize, bringing back brandy and dry provisions, their only food, as they are too indolent to plant anything in the fertile grounds around their decaying huts. Only where Yucatan Indians have settled among them, a cornfield, a banana plantation, or fruit-trees are to be found. Whenever it was possible to make short excursions without too much delaying my voyage, I examined the country along the river. Some specimens of petrifactions from the calcareous ridges, when broken by the current of rivulets, were procured; also a number of land and fresh water shells, and some birds. When no convenient settlement of Belize merchants or Indian houses could be reached, we were wont to camp in the forest, using the leaves of the corossa or cahoon palm for shelter and protection.

In San Pedro Buenavista I found waiting for me mules and muleteers, which the corregidor of Peten had sent on at my request. For the transportation of smaller articles I had counted upon Indian carriers from the villages near this place, who generally serve in that capacity in the trade between Belize and Peten. But the recently received news of a revolution which had broken out in Peten made those Indians unwilling to go to that place, and I was obliged to stop in San Pedro until messengers, sent through the wilderness, could procure from the corregidor of Peten the necessary number of carriers. More than a month passed before they arrived, a month lost for explorations, as the necessary vigilance over my baggage in an unclosed hut, among thieving negroes, forbade my being absent from the place. Some few reptiles, fishes, coleoptera, and molluscs were, however, collected. The villages in the neighborhood of this farm are of late origin, peopled by Indians from Yucatan, almost every one of them formerly engaged in the war of races which for the last twenty years has desolated that unhappy country. From my host, who kept some merchandise for trading with them, and who employed some of their men as laborers on his farm, I had opportunity to become acquainted with many of them, and obtained interesting information as to their social and political condition. They are by no means hostile to the white man in general; their hatred is directed against the Mexican and Spaniard only, while they are friendly to other foreigners, and are remarkably frank and outspoken with such strangers as speak their language and know how to gain their confidence. The insurrection of the Yucatan Indians broke out in 1847, and spread in the following year almost over the whole peninsula, approaching as near as sixteen miles to Merida and three to Campeche. A Catholic priest, sent as commissioner by the Meriden government among the insurgents, caused a division among them which still continues. Those of the south and east, known by the whites of Yucatan as the Huithes,* but who call themselves Cruzoob,† or Cruzes, have continued an uninterrupted war against the Meriden government, while those of the west have remained in peace with the whites, and even acknowledged a certain dependency on the government of Campeche. They are called Pacific Indians. In the year 1857 the Cruzes invaded the Pacific Indians of the district of Chichanjá. Since that time the Pacific Indians of that district have settled in the formerly uninhabited *montaña* (forest-plains) around the frontier between Yucatan, Peten, and Belize, and their number has been increased by numerous deserters from the ranks of the Cruzes. They all, threatened by their common enemy, the Cruzes, retain certain connections with each other, although those on Belize or Peten territory have formed villages under the authority of the English and Guatemalean governments, while those in Yucatan and in the region of doubtful pertinency ‡ remain subject to the chiefs of the Pacific Indians. To those who only know about the insurgent and independent Maya Indians from the reports of their barbarous warfare against the whites of Yucatan, it is highly surprising to see these ferocious warriors organizing themselves without any external influence as quiet settlers, laborious and orderly, submitting to their self-elected local authorities,

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* *Huith* is the breech-cloth.

† The Spanish word *cruz* (cross) with the Maya plural termination *oob*. They worship the cross, in whose name the Tat-ich (their head chief) and twelve governors (military chiefs, priests, and counsellors) govern.

‡ The limits between these three countries are most uncertain. A decree of the Spanish government fixed in 1787 the boundary line between the intendencies of Yucatan and Guatemala on the parallel 17° 49′ north latitude, but it has never been ascertained where this parallel runs. A treaty between England and Guatemala has adjusted a boundary line between the colony and the republic, running from Gracias a Dios on the Sarstoon river to Garbutt falls on the Belize river, and hence northwards. The map of the colony (published *s. l. et a.* but London, 1864) runs it to the 18th degree, into the undoubted territory of Yucatan. The actual jurisdiction of Peten comprises all the villages on and near the road from Peten to Yucatan, up to Becanchop, ten miles north from Nojbecan, near the 20th degree, while the country to both sides is subject to Mexico, and the census of the State of Campeche (1861) includes all these villages into its territory

honest in their dealings, rigorous against criminals among them, and by far the best class of people in either the British colony or Peten. They are Catholics, and are proud to show their abomination of the heathen worship of the Cruzes. I have been shown a long memorial, written in the Maya language, containing numerous letters, orders, proclamations, etc. It states their motives why they separated from the Cruzes, the principal and repeatedly asserted reason being—"We are a Christian people." As to the number of these Indians, the most discordant opinions exist. According to such Belize and frontier traders as are the best judges, the Cruzes do not number less than 10,000 and probably not more than 15,000 warriors, and of these half their number only are married. Estimating a family to consist of five souls only on an average, would give for their whole number about forty thousand; and the number of the Pacific Indians is considered but little less. Both together occupy about one thousand square miles.

The main road from the last settlements on the Belize river to Peten leads through immense forests, with very few and inconsiderable elevations of the ground. The Sierra de Yucatan, which in our maps diversifies this region, does not exist. The general direction of the road is from east to west. At distances from 10 to15 miles, in places where water, food for mules, and palms for camp building are near at hand, the usual resting places of travellers are situated. We left the main road at one of these places called San Clemente for another shorter road recently opened by the Corregidor of Peten for my convenience. It led to the village of Macanché, on the lake of the same name, and thence to Remate, a deserted hamlet on the eastern end of the northern portion of the Chaltuná, or Peten lake. This lake, it is well known, has almost the shape of a horseshoe. Here we found canoes from Peten awaiting our arrival, and were paddled by our carriers in twelve hours along the northern curve of the lake and round the point of Nimá to the city of Flores. This is situated on the rocky island of Remedios, in the entrance of the southern portion of the lake, and not more than a mile distant from the southern shore. The valley or depression occupied by this lake and two smaller ones is surrounded on all sides but the southeastern by chains of calcareous hills from 200 to 500 feet high, covered with stately forests. A peninsula which, running from east to west, divides the northern section of the lake from the southern, is studded with low hills, many of them being artificial mounds upon which are scattered the dilapidated remnants of ancient buildings.

The department of Peten, the largest of the seventeen into which the republic of Guatemala is divided, covers the immense area of from 4,000 to 5,000 square miles, with about 8,000 inhabitants. They live chiefly in the villages in the savanna region to the south and northwestern shore of the lake. The country in its general character is flat, covered with immense forests, and watered by the numerous rivulets which constitute the head waters of the Belize river, the Rio de la Pasion, and the Rio de San Pedro. The Rio de la Pasion divides, in its western course, the departments of Peten and Verapaz, receives the Lacantun river from the mountainous department of Totonicapam, and, breaking through the chain of mountains on the frontier of Tabasco, emerges into that Mexican state called there Usumacinta. Near the Passion river the land is low, full of swamps and lakes, and subject to annual inundations. The climate is warm but mild, with remarkably small daily or annual changes of the thermometer, which ordinarily ranges between 70° and 80°; the lowest and highest observations during more than a year were 62° and 89°. The rainy and dry seasons are the same as in Yucatan and Tabasco, and the season of north winds is here, as also in the interior of these states, marked by mist and drizzly rains. The country is one of the healthiest in the tropics, and the average duration of life longer than in most other countries of the same latitude. The prevailing diseases are intermittent and remittent fevers throughout the year, and dysenteria in summer, but of a mild

character. The yellow-fever has never apppeared, though the cholera has made great havoc among the Peteneros.

The inhabited part of Peten is separated by wide deserts from all the surrounding countries. The traveller is obliged to journey, in going to Yucatan, nine days, to Verapaz and Guatemala eight days, (in bad weather eleven,) and to Tobasco and Belize six days, through an uninhabited country. The Spanish settlement in this region, after the conquest of the Itzas in 1697, was for half a century only a military outpost with a small garrison from Guatemala. Afterwards it was used by the government of that dependency as a criminal colony, *(presidio.)* The offspring of the prisoners, of their keepers, and of the natives, with some admixture of negro fugitives from the coast, together with the rests of the Lacandon tribe on the Passion river and the immigrated Maya Indians of the *montaña*, form the actual population of the department. In their isolated situation and at a distance of about 270 miles from the city of Guatemala, they necessarily have remained in a rather primitive state. The *ladinos*, or so-called whites, (though with a good deal of mixed blood,) form a kind of patriarchal aristocracy. The Indians and negroes are the field-hands and house-servants of the whites, under the system of peonage, as in some parts of Mexico and Central America, obliged to serve the master to whom they are indebted until their debt is paid. Others live free in the villages, subject to the local authorities appointed by the government. The corregidor is at the same time civil governor, military chief, judge, revenue collector, and postmaster. Ecclesiastically subject to the bishop of Guatemala, a vicar and two curates are assigned for the spiritual administration of the whole department. The raising of cattle and horses is almost exclusively the business of the country; oxen, horses, hides, moccasins for the negroes of the British colony, a little coffee, wild cocoa, India-rubber, and kalá (the palm leaves of which the so-called Panama hats are made) are their only articles of exportation. The returns consist in cheap merchandise, dry goods, hardware, etc., imported from Belize. Such is the state of agriculture that in the richest soil there is scarcely produced the necessary quantity of Indian corn beans, sugar-cane, tobacco and Sisal hemp for their own consumption. All the land belongs to the government, but is free for the use of every one. Schools exist nominally in the city and larger villages, but they are for the greater part of the year closed on account of the want of funds. There is little division of labor; every one builds his own house, raises his own corn, and, if he has the means, some cattle, hogs, and chickens. Every one is by turns butcher or baker, and sells meat or bread, (the latter only in the city,) and makes his own soap and candles. Almost all make moccasins, and a few industrious persons occupy themselves, besides raising their corn, as carpenters, tailors, and silversmiths. No store, no physician, no apothecary is to be found in the country. The people, poorly educated, unrestrained, and with but few necessities, lead a lazy and sensual life, much given to gambling and intoxication, and joining now and then in a petty conspiracy, or even in an open revolt. On the other hand they are good-natured, kind and hospitable; crimes against persons or property are of rare occurrence. In their social intercourse they exhibit the mild and polite manners characteristic of the Spanish-American, and in their external behavior they are far above the same classes in more civilized countries of America and Europe.

The city of Flores during the last 15 years has been reduced to half its former size by a continuous rising of the lake in the midst of which it is situated. This is occasioned, it is supposed, by the stoppage of a subterranean outlet. It has now about 900 inhabitants, who live, crowded together, in miserable huts built of sticks covered with mud and roofed with palm leaves. The connection with their fields and stock, which are on the main land, is effected by frail canoes, and is often altogether interrupted when a northern wind strongly agitates the waters of the lake. I found here, as everywhere in the country, the most friendly reception, thanks to the special orders of the government in my behalf and to the

natural kindness and hospitality of the people. During a month which I remained on the island, I made some excursions on the lake and to the mainland, collecting specimens and examining some points of special interest to archæology. The difficulty of movements from this place, however, decided me to choose another centre for my further explorations, and I changed to the village Sacluk, about 20 miles to the southwest of Flores, situated in the savanna region, half way between the lake and the Passion river. The prairie lands, bordered at the north by the forest hills surrounding the Chaltuná lake, and to the south and west by the woods along the Passion river and its tributaries, are of a peculiar formation. An alluvium of red clay,* covered with a stratum of humus form three to eight inches thick, on which gramineæ of great variety and only a few species of small trees grow, is intersected by numerous groups and chains of low conical hills from 30 to 120 feet high, formed by large calcareous rocks (some with caves) and boulders. In the northern part these hills are covered with wood and forest trees; in the southern part they are, like the plain, covered only with grass and small prairie herbs. The country, divided into numberless smaller and larger valleys, many of them adorned with lakes, around which the cattle feed, forms a beautifully varied and picturesque landscape. From this point I made numerous excursions in all directions; I surveyed part of the Rio de la Pasion and a number of its tributary rivers and lagoons, all of them located erroneously and with false names in the existing maps, thus collecting the material for the completion of a map of southeastern Mexico, which has occupied my leisure hours during a number of years. Among the Peten Indians and the Lacandones of the Passion river, who both speak dialects of the Maya language, I found favorable opportunity to continue my ethnological and linguistical studies, and was enabled also, by occasional meetings with Indians from Cahabon and Caban, to add the Quecchi to my collection of vocabularies of languages belonging to the region between the isthmus of Tehuantepec and the other of Honduras.

Of all the Indians of this part of Central America none are of so great interest as the Lacandones. Once a numerous and powerful nation, which, united with the Manchés and Acalanes, (both now extinct,) gave so much trouble to the conquerors, and, in fact, have never been fully subjugated, they are reduced to-day to a very insignificant number, living on and near the Passion river and its tributaries. Some old authors distinguish the eastern from the western Lacandones, and it seems that they were, in fact, as well as those of the west, of different tribes, living on the borders of the Mexican state of Chiapas, speaking a different language, called *Putum* or *Chol*, which belongs to the family of languages connected with the Maya. To these western Lacandones are referred the stories of a large inaccessible city mentioned by Stephens. They live far from the settlements of the whites and do not trade with them, nor do they entertain any relations with the eastern Lacandones, who fear and avoid them. The eastern Lacandones are a harmless tribe, who live in small palm huts, consisting of little more than a roof, and grouped into little hamlets of a few families, often changing their locality. They cultivate the field, plant fruit-trees, sugar-cane, and Sisal hemp; search the woods for wild cocoa, beeswax, honey, and other products of the forest; hunt with bows and stone-headed arrows, and navigate, by means of their small canoes, the lagoons and rivers from which they obtain plenty of fish and turtles. Although occasionally baptized by Catholic missionaries and fond of saying their prayers, they still adhere to their old heathen worship, and indulge in polygamy, keeping as many wives as they are able to purchase or to steal. They visit the villages of the whites and settled Indians to sell their produce. Having adopted a little orphan boy of this tribe, and speaking their language, I soon won their friendship. They have, in my excursions on the water and in the woods, been of the greatest utility to me, as also to the

* On occasion of the excavation of a well in Sacluk I saw the clay reaching a depth of 50 feet, intersected at about 30 feet from the surface by a small layer of pebbles.

corregidor, who, with their assistance, has found a new route through the unknown wilderness to Verapaz and Guatemala, which was long in vain searched for, and which reduces the distance to less than one-half of that usually travelled.

In the month of October, 1866, I was planning my departure from Peten further west, and had ordered the required remittances from Belize, my base of supplies, when troubles among the Indians in the British colony arose and changed all my plans. One of the many blunders of the unhappy Emperor Maximilian, who, with the best intentions, knew too little of the country which he thought so easy to reform, and who was especially unlucky in the choice of his employés, was a proclamation to the Cruzes, inviting them to a full amnesty, but threatening to destroy the very last of them if they would not submit to his fatherly entreaty. The Cruzes were at that time in greater part tired of the war, and, undisturbed by the whites, had commenced to remain quietly in their districts. The menace stirred them up again, and they armed themselves for resistance with the war implements and supplies which they could readily obtain from the English traders. Maximilian's troops finally did not succeed in their operations against them, but had to retreat after a fruitless campaign, much reduced in numbers, though consoling themselves with boastful reports of sham victories. The Pacific Indians, seeing the Cruzes again on the war-path, and fearing a long-threatened attack of their old enemies, armed also. One of their military chiefs got into difficulties with the Belize wood-cutters, on account of abuses committed by the English against the Pacific Indians in the colony, and also within the territory of the independent Indians. An insurrection of the Belize Indians followed, in consequence of which all wood-cutting establishments in the colony were abandoned, and all communication between Belize and Peten cut off. The English, after two resultless campaigns, succeeded in setting the Cruzes against their enemies, and a general stampede of the Indians of the montaña was the consequence. These movements caused a frightful panic among the people of Peten, who are not much given to fighting and always afraid of one or the other invasion of their country, which they imagine to be superior to any, and coveted by all other nations. Fugitives from the colony and immigrants from the montaña kept us posted on all occurring events. I learned that part of my supplies, despatched from Belize before the outbreak, had been stored in some hut on the Belize river and had disappeared. Month after month I waited in vain for an opportunity to communicate with Belize, and all efforts to establish a correspondence with the Gulf coast were fruitless. I resolved to go myself to Tabasco and to put myself again in communication with the United States and Europe. In the excited state of the country, where every day an invasion by the much-feared Indians was expected, I could find neither carriers, mules, nor drivers to move my baggage and collections. I considered myself happy to get away with my manuscripts and with the indispensable provisions for a travel through the wilderness, and left Sacluk in April, 1867, for Tenosique and San Juan Bautista, the capital of Tabasco. From this place I despatched my correspondence. A return to Peten during the rainy season being out of question, I used the time which was to pass before answers could arrive for a revision and completion of my former surveys of the Usumacinta, its branches and tributaries, and followed its course upwards 16½ miles above Tenosique, to the so-called "Large cataract," which, however, at that time, with high water, appeared only as a rapid with about three feet fall within a distance of some 20 yards. Above this place the course of the river is entirely unknown in a distance which I estimate between 50 and 70 miles. On my return I visited the ruins of Palenque, and during the trip was enabled to complete a map of the department, and to collect vocabularies of the Putum and Tzental languages, both spoken in Chiapas, and of the Chontal of Tabasco.

I was thus occupied when private business rendered a visit to the United States of importance to my personal interests; but, having concluded it, I am now about to return to the same field to finish my interrupted explorations, and to bring home the collections from Peten.

NOTES OF AN EGGING EXPEDITION TO SHOAL LAKE, WEST OF LAKE WINNIPEG.

MADE UNDER THE DIRECTION OF THE SMITHSONIAN INSTITUTION IN 1867, BY DONALD GUNN, RED RIVER SETTLEMENT.

On the 6th of June, 1867, I had all things ready for commencing my hunting excursion to the lake; but, to my chagrin, the rain fell in torrents on the 7th 8th, and 9th, which prevented our setting out till the morning of the 10th, when the rain had moderated; and about 7 o'clock a. m. I left home, accompanied by two men, two oxen in two carts, carrying a birch-bark canoe and our baggage. We plodded on through "mud and mire," travelling very slowly a distance of 15 miles on the public road to the Frog plain, where we turned off to the plains, taking the road leading to Shoal lake, in a northwest direction. Soon after we entered on the plain we halted to allow our animals to feed and to refresh ourselves. While here we were joined by an Indian, his squaw, and their son. These people had been to the settlement with their spring trade. They had two carts, and were taking back, in exchange for their furs, flour, clothing, and ammunition. This Indian resides in a house at Oak Point, and is reputed the best hunter in that district, which fact accounts satisfactorily for his comparative wealth. After a short stay we resumed our journey, which was continued until dark, making a distance of six miles from the settlement. We camped on the plain, and, after the usual preliminaries of cooking and supping, laid down to rest under a cloudless sky, and slept soundly until sunrise of a clear day.

The unburnt portions of our last night's fuel were quickly gathered together and ignited, water drawn from the nearest pool, boiled, a liberal quantity of tea thrown into it, boiled again for a few minutes, then allowed a short time to cool, when we all sat down and despatched our morning meal with great zest; attached our cattle to the carts, and were on our journey before the sun was a span high. The road led us over a beautiful, dry, level plain, a distance of six or seven miles, at the end of which we came to a ridge of elevated land composed of limestone, gravel, and granite boulders. This ridge is well wooded with poplars, and is a continuation of the Grand Coteau at Long lake. Back of the Assiniboine its course is from northeast to southwest. It appears to have been the border of, or an elevation in, some ancient lake in ages long gone by. Lake Winnipeg might have flowed round it or washed its southeastern face. It extends eight or 10 miles in breadth. The declivity on the northwest side is gradual but perceptible, and ends at what is called the Big swamp, where we arrived at noon. Here we overtook our companions of last night, and a heroic dame from Oak Point, who left her home a few days before for Red river, and was now on her way back with two cart loads of pine boards and planks. She has a considerable portion of white blood, yet exhibits all the hardihood of the squaw, and can, with wonderful dexterity, avail herself of all the resources of the forest and the lake. Here she made a few snares, chased the rabbits into them, and in a very short space of time had a number of them boiling and roasting, and after hunting, cooking, and eating her dinner, was ready to start as soon as any of us.

After a stay of two hours we proceeded on the road leading over a flat, rich soil, composed of black, vegetable mold on a sub-soil of clay, and winding through hundreds of young poplars, tall and slender, but, so far as we could see, unfit

for building purposes. On the right the forest extends to Lake Winnipeg, near which pine and tamarack abound, which, at some future period, will be used for building materials in this region. About 5 o'clock we arrived at the ridge; unyoking our cattle we gave them some time to drink and feed. In a very short time two or three fires were blazing and several of our party were running with their tin kettles to bring water, which was soon converted into tea; after which we sat down in groups to enjoy this evening meal without the luxury of plates, knives, or forks, &c.; some, for the former, using a few poplar leaves; others a bunch of green grass; and for knives and forks their teeth and fingers. After eating, pipes were called into operation, and after smoking, stretching, and rolling, we, by mutual consent, harnessed our cattle and left this delightful place. This ridge runs parallel with the other, and is composed of similar materials—abrupt on the southeast side, but, once on the summit, the declivity towards Shoal lake is imperceptible. A short time before sunset we sighted and were soon after travelling along this irregular sheet of water, neither fresh nor salt, but containing enough of the latter ingredient to render its water very bitter and unpalatable. As we passed along the lake, I observed a stone pillar, or cairn, formed of small granite boulders thrown loosely together, and on inquiry of my companions from the lake "What mean ye by these stones?" I was informed here, in 1843, in passing from Red river to Manitowaba to establish a mission among the natives, the Rev. Abraham Cowley and party passed their first Sabbath in the wilderness, and that these stones were set up to commemorate the sermon preached on the occasion. We continued our journey some time after sunset, and finally encamped for the night where we had plenty of wood and good water. On the morning of the 12th we left camp about sunrise, continuing our journey along the lake, intending to pass round to the north of that part of it along which we were travelling, then turn to the south through the point opposite where we were, and at a distance of five or six miles from us, to a rather deep bay in that point, it being the only place where we found the grebes in any considerable number when I was there in 1865. That year we encamped on a point running into the lake from the south and at some distance to the west of the narrows. We had to find our way to the breeding places, which consumed some time, and proved inconvenient on account of its distance from where circumstances compelled us to stop with our carts and oxen. Moreover, on account of a great storm of south wind that sprang up and continued for 48 hours, we were prevented returning to camp with the products of our hunt until both birds and eggs were beginning to spoil, and adding considerably to the distance in going to Manitowaba lake. To avoid these inconveniences I intended, as stated above, to follow the west side of the lake, turn round the north end of that bay, or arm of it, and then proceed south to the bay where we formerly made our hunt. On inquiring of our Indian companion as to the kind of soil to be travelled over in going into the point, he represented it as full of quagmires, and altogether unfit to bear oxen and carts. This tale, which in a few days after we found to be untrue, and only showing the Indian jealousy of intruders on their hunting grounds, made us stop on the west side, whence we had to go six or seven miles to hunt.

In the first part of the day we secured some eggs and birds—among others a pelican. I remained in camp to clean the eggs and skin the birds. The pelican was a female: she contained four eggs of a large size, with some smaller ones. None of them had any shell, and I am inclined to think that the flock of which she formed a part was on its way north to some breeding place, probably Lake Winnipeg. They have for some years forsaken this place, being continually disturbed by egg hunters. After gumming our canoe, my men (an Indian and my youngest son, who accompanied me in 1865) set off for Grebe bay. Late in the evening the wind blew strongly from the southwest, bringing torrents of rain on its wings, against which my only defence was an ox-hide. The rain, with

some short intervals, continued during the following day. The third day was dry and clear. In the evening our hunters returned, bringing ducks, grebes, and eggs in abundance. On their arrival at the hunting ground they were not a little surprised to find others there before them. These people were from Manitowaba lake, having transported their little dug-out canoes on carts drawn by oxen over the very ground which our Indian friend had represented as one continuous quagmire. However, as we had already made a good beginning, we decided on remaining where we were, and extended our excursions thence. As soon as we had skinned our birds and emptied their eggs we took to the lake for more, which operation we repeated from day to day, until we had secured a considerable number of specimens.

The annual resort of the *Podiceps occidentalis* to Shoal lake is, as has been observed, "remarkable." From the most reliable information that I could obtain from the Indians at this place, it has never been seen on the Red river, nor on Lake Winnipeg; and I never heard of its having been seen anywhere in what is commonly known as Rupert's Land, except at Shoal lake and Manitowaba; and I may add that it is also remarkable that there are very few grebes to be found in any other of the bays connected with the lake, although all these bays abound in reeds and rushes. Possibly these birds prefer the bay on the north point, on account of its being sheltered from the wind; and probably a greater facility for obtaining food in that locality may influence them in the choice they make. I am inclined to think that the large grebes feed on aquatic plants. I opened several of their gizzards and found nothing in them but grass. The western grebes, when seen in groups on the smooth, unruffled waters of the lake, make a splendid appearance, sometimes raising themselves out of the water and flapping their wings, their white breasts glistening in the sun like silver. They are not timorous, but when alarmed they sink their bodies in the water, and if the object of their fear still presents itself they plunge head foremost and dive, and continue a long time under the water, often disappointing the expectations of their pursuers by reappearing in a different direction from that anticipated. They make their nests among the reeds, on the bent bulrushes of the last season; the frame or outer work is of reeds and lined with grass from the bottom and reed leaves. The nest is nearly on a level with the surrounding water, and may be said to float at its "moorings," held there by the reeds. We found hundreds of these nests, containing two, three, and four eggs each; I believe six to be the highest number we found in any one. We took 13 grebes, of which the males were larger than the females; the largest males measured before skinning, 27¼ by 36¼ inches, and 14 inches round the body at the heads of the wings. The largest female measured 24½ by 32½ inches. We shot not a few of them in the act of leaving their nests, and most of them on being skinned proved to be males; which fact inclines me to believe that the male bird takes his turn in sitting on the eggs.

The *Podiceps auratus* are very numerous in this bay. They make their nests on the bulrushes, composed of the same material. We found as many as six eggs in some nests, but in the greater number of nests only four. They are very shy and expert divers; are very common on the Red river, and breed in the marshes near the lake.

I may here observe that great numbers of night-herons breed here. They fix their nests to the reeds eight or nine inches above the water, and deposit in each four or five roundish, blue eggs. I think this is the only place in Rupert's Land where this species is found. We gave them the "go-by" last summer. The Indians call them kitché-geskman, *i. e.*, big king-fisher.

Ducks and their nests are found everywhere round the lake. The ruddy duck is sometimes found in swamps near this river, but they are more numerous at Shoal lake and Manitowaba.

There are numbers of terns breeding annually at Shoal lake—some of them

on small, gravelly islands. These form their nests by removing the gravel, making hollows in which they lay their eggs; others of them take up their abode among the reeds and rushes. Here with great industry and ingenuity they make their nests of reeds and grass, fixing them in their place to keep them from floating away. When in Lake Winnipeg, in 1862, I observed that the terns which occupied sandy and gravelly islands made their nests as those do on the gravelly islands in Shoal lake; and the terns found on the rocky island on the east side of the lake chose for their nests depressions and clefts in the surface of the rocks. These they line carefully with moss, three or four eggs being laid in each nest; thus exhibiting a remarkable example of instinct, which teaches these little creatures that their eggs laid in soft sand and in loose gravel are safe without any lining to protect them, but that when laid in hollows and clefts of rocks, lining to protect their eggs and young from injury by these hard and at night cold materials would be indispensable.

All round the lake there is an abundance of wood, with many fine, open plains in every direction, offering great facilities and promising rich rewards to the industry of the husbandman. The only drawback in the way of making settlements at this lake is its bitter, disagreeable water.

After a stay of ten days at Shoal lake we set out early in the morning for the Pitoo-Winnipeg Manitowaba. We found a well-defined cart road leading to Oak point. On our way we met a young half-breed from the bay going to Grebe bay. He had his "dug-out" on a cart drawn by an ox. He stated that his object in going there was to hunt muskrats and collect as many eggs of all kinds as he could, to take home to eat. As these people neither sow nor reap, they have to subsist on what the seasons afford. After travelling for 10 or 11 hours over a dry, level road, we arrived at Oak point in the afternoon. Here we stopped a short time to dine and give our cattle time to feed and rest. Afterwards we proceeded to the lake, where we saw great numbers of those beautiful birds, the Franklin gully, soaring over the water near the shore, and at short intervals plunging in to seize their prey. We could have secured numbers of them if we had had stuffing material. The following days we hunted in marsh, but found very few gull eggs. We procured some duck nests, and among them were two *Athaya Americana*, (red-head ducks' nests,) one containing eight eggs, the other 19. When I was there in 1865 we found one belonging to the same kind of duck containing 19 or 20 eggs. The Indians accuse this duck of dishonesty, stating it to have very little respect for the rights of property, being inclined to rob other ducks of their eggs and place them in its own nest. This species and the canvas-back are both found at Shoal lake and at Manitowaba, but nowhere in great numbers.

While here I was attacked by a cutaneous disease, which affected my eyes very painfully. After a residence of three days we turned our faces homeward. The morning was fine and bright; in the afternoon the clouds gathered fast from the south. The night overtook us before we crossed the plain at the south end of Shoal lake. We found some water for ourselves and cattle, and laid down to rest under one of our carts. Soon the rain began to pour down in torrents, the wind blew hard, driving the rain through all our defences, and in a short time blankets and clothing began to communicate anything but a pleasant sensation to our chilled frames. But the night was dark, and we had to keep our post until daylight, every moment expecting that the lightning would strike our cart and most probably terminate our journey; and, unfortunately, our specimens got wet and considerably injured. We attached our oxen to the carts and were moving off before sunrise. At 8 o'clock we halted at the Big ridge; while there the sun began at times to peep through the broken clouds, the rain ceased, and at last the sky became clear and the air warm. The road was in many places covered with ponds of water, rendering the travelling slow and unpleasant. At noon we halted at the Big swamp, had dinner, and afterwards resumed our

journey, the weather and road improving as the day advanced. At sunset we came to our first camping place from the settlement, men and oxen being very tired, and I very unwell and nearly blind from the affection of my eyes; we were, however, much improved by a good night's rest, and left camp after sunrise. In passing over the plain we shot a meadow lark; these birds are found in pairs along the Red river to the end of the plains, and on the south side of the Assiniboine. They appear in pairs in May, generally perched on a low tree—willow or reed. They are very watchful, seldom allowing the hunter the chance of a fair shot. We found the public road much improved since we passed on it, before; the tempest which passed over us at Shoal lake did not extend to the settlement. We reached home at 3 in the afternoon, and found "all well."

It may not here be amiss or out of place to make a few remarks on the Manitowaba region. I have travelled a distance of 40 miles on the east side of it, and am delighted with the beauty of the landscape; the wide expanse of water in the foreground, the dark green forest in the rear, with a beautiful green plain of three or four miles in extent, gently declining from the forest to the lake, inviting the husbandman to put in the plough. Here are neither stones nor roots to impede his operations, and I am sure the soil is generous and would amply repay his toil. This large lake abounds in a variety of fish of the best kinds, which an industrious population would turn to profitable account. In this region there are at present three small villages: one at Oak Point, containing from 10 to 15 dwellings, called houses, of the most primitive kind; another at what is called the Bay, consisting of seven or eight houses, and favored as the residence of a Catholic priest. A third village is rising two or three miles to the south of the latter. The population of these villages is composed of Indians, of half, three-quarter, and of seven-eighth Indians, with a few very aged French Canadians. These people are like the fowls of heaven; they "neither sow nor reap," nor do they even, as far as I have been able to see, plant potatoes. They possess a few cattle and horses; the latter roam through the woods summer and winter, living independent of their masters' care. The finest of hay grows within a few yards of their houses, yet I have been informed that many of these people are so indolent as to allow their animals to die in winter from starvation. There are two or three exceptions to the above rule. The question will naturally arise, how do people so bound down by indolence procure food and clothing? In answer to this query we will begin with the opening of the spring. I said above that the lake abounded with fish. As soon as the thaw commences the fish forsake the deep places to which they resorted as the winter advanced, and swarm towards the shore, and run into the many little creeks that pass out of the marshes into the lake. Here they are taken in nets and by angling from the beginning of April until the breaking up of the ice in the latter end of May, and for some time after continue plentiful until the water in the lake becomes warm, when the fish return again to the deep places. In April the ducks and geese return in great numbers, become plentiful, and feed in numerous flocks in all the marshes fringing the lakes for at least a month and a half. The gray geese and ducks draw off by degrees in May, but the white geese (wawee) come generally in the last week of April, and begin to clear away for Hudson's bay on the 13th or 14th of May, where they invariably arrive on the 15th of May; the last of them leave here from the 20th to the 25th of the same month.

While the fish and wild fowl can be had these people enjoy a continual feast; and when these fail, rats, which have been taken in great numbers for some years past, are considered desirable articles of food; even when plenty reigns in the land the rat furnishes them not only with food but with the means of providing themselves with clothing. Since the country has been partially opened the furs are busily competed for, and it follows that a high price is invariably paid for them. When all the wild fowl have taken to their breeding places the people have a hard struggle for dear life against hunger, which compels them to search

along all the lakes and marshes for eggs, and for every other eatable that falls in their way; and during the month of July and part of August they suffer much privation of food, unless possessed of means to enable them to draw on the settlement for flour; but when the young ducks take to their wings and the fish begin to approach the shore, they are able again to set hunger at defiance for a time. In the beginning of October the fall fishing commences, *i. e.*, the white fish (the a-ticki-meg of the Indian) approach the shore and the shoals for the purpose of spawning, and if the season be favorable those who command a little industry and plenty of nets will be able to lay in a good stock for winter use; but when the fishing fails and the rabbits disappear, as the case is this year, these people are, indeed, brought low—even to starvation's door. Flour is selling there this winter at 40*s.* per cwt. Another trait of these people of primitive habits and manners is, that, although occupying these villages for a long time, they have neither president, council, nor magistrate, and I never heard of any crime of any kind being committed by any of them except once, and that was a case of manslaughter which arose out of undue provocation.

SKETCH OF THE FLORA OF ALASKA.

By J. T. Rothrock, M. D.

A complete list of Alaskan plants with a detailed account of their geographical distribution cannot yet be expected. But a small portion of our newly acquired possessions has been at all explored by botanists; indeed, if we except Sitka and its immediate surroundings, we may say *no part* has been thoroughly investigated. Future researches will not only add much to our knowledge of the species known to exist there, but will largely increase that list. The strip of land extending south from Mount St. Elias to the Steekine river would well repay exploration, either from a commercial or a scientific point of view. It is almost a matter of certainty that this will be found to have a large number of more southern species extending up into it.

It may not be amiss, in passing, to glance at the timber and prairie lands of British Columbia; lying, as they now do, between our possessions, our interests must be materially affected by them. The forests of British Columbia west of the Coast range, and perhaps as far north as the Steekine river, are for the most part made up of the following trees:

Taking them in the order of Dr. Lyall, in his report on the botany of northwestern North America, we have first in size and commercial importance, *Abies Douglasii*, Lindl., (Douglas' spruce,) from 225 to 250 feet high, and often 12 or 13 feet in diameter. This tree has acquired already a great commercial value in the lumbering trade of the coast. It is said by Dr. Lyall to make good spars; it has a fine, clear "grain," and is destined to become more important as the resources of the country are developed. The tall flagstaff in the royal gardens at Kew is made of a single trunk of this tree. It is also found more in the interior of the country, in the valleys of the Rocky mountains.

Abies Menziesii, Lindl., (Menzies' spruce,) a somewhat smaller tree than the last-mentioned, though still a titan.

Abies Mertensiana, (Mertens' spruce,) from 125 to 200 feet high, and with a beautifully straight trunk, which, as Dr. Lyall remarks, often grows 60 or 70 feet high before giving off a branch. It is found as far north as latitude 57° on the shores of Norfolk sound.

We will insert here *Abies Canadensis*, which is said to have been found by Mr. Tolmie as far north as latitude 57°, on the shores of the Pacific, and by Mertens in Sitka. This tree, though of large size, is very inferior as timber. The bark may be turned to account in tanning.

Pinus contorta is found throughout the valley of the Frazer on high grounds; it grows from 25 to 50 feet high and a foot in diameter. On the upper Frazer this tree is eminently social, and one often finds mile after mile of forest made up exclusively of this tree. In the spring months the Indians are in the habit of stripping off the outer bark and scraping the newly-formed cambium from the trunk; this is eaten either in the fresh state or dried and pressed into compact masses

The present report on the botany of Alaska was prepared at the request of the Smithsonian Institution, by Dr. J. T. Rothrock, professor of botany in the Agricultural College of Pennsylvania. The original material committed to his charge consisted principally of the collections made by employés of the Western Union Telegraph Company, in their explorations connected with the Russian overland telegraph expedition, Dr. Rothrock himself among the number.

JOSEPH HENRY,
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for future use. Early in the season the taste is not unpleasant, and the effect is that of a gentle laxative; but later, when the tree has fairly commenced its summer work, and begun to elaborate its peculiar terebinthinate principle, it is too strong for other than Indian palates, or except as a last resort against starvation. This "girdling" of these trees has resulted in an extensive destruction of them near the Indian villages.

Thuja gigantea, Nutt.—This magnificent tree grows sometimes to a height of 170 feet, and to a diameter of 10 feet and over. The timber is light, easily worked, and tolerably durable. I am not certain that it is found north of the 51st or 52d degree of latitude. I have seen boards 20 feet long split from it by the Indians. From it in part the celebrated "northern canoes" are made. These canoes, "dug" from the single trunk and afterwards steamed into shape, will often carry four tons. From the wood the Indians also manufacture paddles, dishes, and boxes, some of them exquisitely neat. From the inner bark they twist ropes of great strength; mats, hats, and baskets are also woven from the same material. The liability of the wood to split when exposed to the sun is rather a disadvantage.

Acer macrophyllum (Large-leaved maple) is found in the valleys of the Pacific slopes as far north as latitude 55°. This tree attains a height of 70 feet and a diameter of two or three feet; its wood is perhaps the best substitute on the Pacific coast for the hickory of the Atlantic slope; the Indians use it to make snow-shoes, spear-handles, and axe-handles; from its inner bark they weave baskets, hats, and mats so closely as to hold water. Leaving the headwaters of the Frazer and crossing the mountain range to the west in latitude 55° north, I met this tree first, growing in company with *Thuja excelsa*. On the upper waters of the Skena river I found the Indians using it in preference to any other wood, as fuel, during the long, cold winter nights; frequently they have completely denuded the hill-sides of it. Lower down on the Skena the cottonwood and Thuja mingle with the maple in about equal proportions. The forests there present a most cheering contrast to the sombre hues of the conifers that abound in the valley of the Frazer, and almost remind one of the variegated woods of the Atlantic slope; birches, too, attain there a height they do not reach in the interior valley above mentioned. Nowhere have I seen forests more beautiful than those near Rocher de Bouller on the lower Skena.

Before concluding this passage on British Columbia I will add a letter from Major F. L. Pope, who, in mid-winter, made a most trying trip from Lake Tatleh to the Pacific via the headwaters of the Steekine river:

"The timber on the upper Skena for 50 miles northwest of Bear lake is very thick and of the same kind as around Lake Tatleh, *(Pinus contorta and Populus.)* It averages about a foot in diameter. Still more towards the head-waters of the Skena, open, grassy plains begin to appear, growing more and more frequent as you go north; over these are interspersed trees, (still of the same kind,) but growing apart like trees in a park. At the head of the river, about 4,000 feet above the sea level, conifers are scarce and dwarfed, but these apparently are still of the same species. When cottonwoods are met with they are of good size. Passing the summit and descending the valley of the Steekine, which runs north for about 100 miles, we still find the same trees, but not so abundantly. On the upper Steekine are great numbers of small poplars and willows; here, too, I occasionally found some patches of pine, in which the trees were about 12 feet high, with a coarse, red bark, crooked limbs, and large cones. On the benches along the 'Great cañon' there is very little timber, what there is being small pine growing in patches. After getting through the cañon, cottonwoods grow in great abundance on the points jutting out into the river; associated with them are alders and willows without number. As near as I can remember there are no cedars *(Thuja)* until you approach the coast. I do not recollect seeing any maples, though there may have been some."

Quercus Garryana, Dougl., which is so abundant near Fort Vancouver, is also found on Vancouver island. Hooker states "the wood is good and well adapted to ship-building." It grows 80 feet high.

Pyrus rivularis grows to be a small tree, and the wood is hard enough to take a good polish; it may be turned to some use in the arts of life; the fruit has a decidedly pleasant flavor, and is largely used by the Indians.

The less elevated prairie lands of the lower Frazer are thickly covered with various species of *Poa*, *Eragrostis*, &c., intermixed with *Vicia Americana*. Even as far north as Fort St. James I have seen the grass and "pea vine" three feet high; these spots afford luxuriant pasturage. At the above-mentioned post of the Hudson Bay Company, (latitude 54° 41′ north,) the horses live nearly the entire year without other forage than such as they find. Mules, however, are not so successful in sustaining themselves when the snow covers the grass, and require "looking after." The swamps are thickly covered with carices; among which *Carex utriculata* predominates in number of individuals over the other species. The high grounds afford the "bunch grass" *(Elymus)* of the packers; so nutritious is this that even when apparently dead and dry, "stock" will become fat on it, and remain so under hard work for long periods if this be plentifully supplied.

Of the main land from Steekine river north to Bristol bay we have but little definite botanical knowledge. Sitka, however, has been well explored, both by Mertens and later by Ferd. Bischoff. We may be said to know its flora pretty thoroughly. Perhaps after the list of plants given on the following pages I can present no better popular idea of the vegetation of this island than by quoting from a letter of Mertens "to a friend in St. Petersburg;" it is published in Hooker's Botanical Miscellany, vol. iii: "If we compare the lofty forests of Sitka (Sitcha in letter) with the wintry coasts of Kamschatka, where, 4° more southerly at St. Peter and Paul, the birch only attempts to rise into a kind of tree, we shall here find a confirmation of that law which proves, by comparing the climates of Lisbon and Philadelphia, Paris and Quebec, England and Labrador, Drontheim and Iceland, that countries situated to the east of the sea possess a milder temperature than those which are placed to the west of the ocean."—(Op. citat., p. 12, prefatory remark by Adrian von Chamisso.) "It [the forest] principally consists of two kinds of fir; the Russians who inhabit Sitka call one of them pine, *(yely* or *jeli,)* the other the larch, *(listwenj,)* though neither of them bears the least similarity to the trees which are thus named in Russia. Both are referable to Michaux's genus *Abies*. The pine, as it is called, seems to me analogous to the North American pine, *(Pinus balsamea.)* Both of these trees must be peculiarly eligible for masts and building timber in general, as they attain an immense height; yet the wood of the pine is not much prized; it is said to be of short duration; that of the larch, as it is called, lasts much longer."—(Mertens in lit. ex. op. citat., p. 16.) "The axe scarcely ever echoed in these woods; indeed, the surrounding wilderness is immense, and strikes the beholder with a feeling of horror. For centuries these trees have never fallen but under the weight of years; and their mouldering remains give rise, without alteration of form, to future generations of trees again to flourish and again to die! Nevertheless, the abundance of shrubs, herbs, and mosses, which clothe these hoary forests, and rise over the natural graves of their former denizens, impart to the scenery an air of vigor and of youth."—(L. c., p. 17.)

After ascending some distance up the mountain sides of the island he finds "the wood, which now appears again in increased denseness before us, consists particularly of a noble *Thuja*, called, on account of its agreeably scented wood, *duschnik*, (scent-wood.) It is the timber most valued here. The tree, indeed, occurs frequently lower down at the foot of the mountains, and even to the sea, but so scattered that it is necessary to search for it among the more predominant pine trees which conceal it from view; but here it constitutes almost the entire

timber, and the pine and the larch are seldom seen—the latter, however, not ceasing so soon as the former."—(L. c., p. 19.)

Mertens completes the picture of the vegetation of Sitka with reports of the species of aconite, aquilegia, claytonia, rubus, saxifraga, epilobium, vaccinium, mimulus, orchids, and sedges, which add variety and beauty to the scene; some of them specifically the same as those growing on the eastern slope of America and in the United States. He also notes a grass *(Poa)* growing two or three feet high; "various ferns, which are, however, types of those which prevail in Russia, grow in great luxuriance."

From Chamisso (in Hooker's Botanical Miscellany, vol. i, p. 317,) we learn that on the peninsula of Alaska (Alaska proper) a few trees are found; but on the island of Ounalashka, which has a more Arctic oceanic climate, the scene is changed; for "a few miserable firs, originally brought from Sitka and planted at Ounalashka, may still be seen, most of them decayed, and the others seem scarcely likely to live."

"At Ounalashka, under the same latitude as Lubeck, the willows scarcely grow higher than the luxuriant grass and herbs of the moist grounds. As soon as we ascend the inferior hills a completely Alpine vegetation appears; even on the least elevated regions of the mountains are some *Vaccinia*, resembling *V. Myrtillus*, which scarcely rise above the ground. Besides the brilliant verdure (due to a moist atmosphere) which here adorns the grass and enlivens the rocks, the lustre of the fresh unsullied snow and of some social plants bestow on this dreary country a rarity and beauty of hue which are quite delightful. *Lupinus Nootkatensis, Mimulus luteus, Epilobium angustifolium* and *latifolium, Rhododendron Kamtschaticum*, etc., are among the most conspicuous. The fresh green of the turf even reminded us of the valley of Ursera.

"The vegetation here appears to have nothing further in common with that of St. Peter and St. Paul than as respects its Alpine flora and the coast plants of these northern shores. Besides such species as are likewise found more north we have only *Lilium (Fritillaria) Kamtschaticum* and the *Uvularia amplexifolia (Streptopus)* common to both places, while on the contrary we found more Kamtschatkan species of plants on the American coast north of Behring's strait, which we missed at Ounalashka. It is the flora of the northwest coast of America which descends to the base of the hills of this island, where it unites with the Arctic flora. As examples of this we may cite *Rubus spectabilis, Lupinus Nootkatensis*, (which may also be found, though dwarfish, on the hills.) *Epilobium luteum, Mimulus luteus, Claytonia Unalaschkensis* and *Sibirica* may also be reckoned here. *Sanguisorba Canadensis, Lithospermum angustifolium* belong to the common flora of America. Many species of grasses thrive in the low lands, with some *Umbellatæ*, such as *Angelica, Heracleum*, etc. A dozen *Carices*, scarcely forming a larger proportion of the vegetation than in the north of Germany, some *Scripi* and *Eriophora*, accompany them, with a few *Junci* in the proportion of about one to two. The *Orchidaceæ* form a group of some importance, both because of the number of the species and the beauty of the individuals. They prevail both in the valleys and on the hills, and we encounter eleven kinds, among them a beautiful *Cypripedium*. Higher north we did not observe a single species of the family. Of the ferns we found about eight species; nearest the pole there is but one *Filix*, and of this we saw but a single specimen. In Ounalashka there are some *Lycopodia;* in the more Arctic regions but one. We found in the lakes many water plants, *Potamogeton, Sparganium, Ranunculus aquatilis;* in the higher latitudes we observed only the two species of *Hippuris* and the common *Callitriche.*" (L. c. pp. 317, 318.)

[I can now enumerate but ten species of orchids. Some are also found north of Ounalashka. The remark concerning the ferns needs the qualification of at least one, and perhaps of two, more species.—J. T. R.]

"At Ounalashka the mosses and lichens begin to assume that prominent station which they hold in all the very cold districts." (L. c., p. 321.)

From all the above we may safely infer that a much lower summer temperature prevails at Ounalashka than on either of the opposite main lands under the same parallel. The comparative height of the snow line is also another evidence of the same thing. At Ounalashka it is but 3,510 feet above the sea level, while exactly three degrees further north and on the Kamtschatkan side it is 5,249 feet above the ocean.

For most of the general results of botanical exploration north of Norton sound we are indebted to the Report on the Botany of the Herald, by Berthold Seemann, and to Dr. J. D. Hooker's paper on the Distribution of Arctic Plants. As will be observed, I quote freely from both these authors.

Seemann says of the truly Arctic region about and north of Behring's strait: "The soil is always frozen and merely thaws during the summer a few feet below the surface. But the thawing is by no means uniform. In peat it extends not deeper than two feet, while in the other formations, especially in sand or gravel, the ground is free from frost to the depth of nearly a fathom, showing that the sand is a better conductor of heat than peat or clay. The roots of the plants, even those of shrubs and trees, do not penetrate into the frozen subsoil. On reaching it they recoil as if they had touched upon a rock through which no passage could be forced. It may be surprising to behold a vegetation flourishing under such circumstances, existing, it would seem, independent of terrestrial heat, but surprise is changed into amazement on visiting Kotzebue sound, where on tops of icebergs herbs and shrubs are thriving with a luxuriance only equalled in more favored climes.

"On the eastern side of America no forests are found above the mouth of the river Egg, about the 60th degree of north latitude. On the western side they extend as far as latitude 66° 44′ north, or nearly seven degrees nearer the pole.

"With a sun shining throughout the twenty-four hours the growth of plants is rapid in the extreme. The snow has hardly disappeared before a mass of herbage has sprung up, and the same spots which a few days before presented nothing save a white sheet are teeming with an active vegetation, producing leaves, flowers, and fruit in rapid succession."

We further learn from Dr. Seemann that even during the long Arctic day the plants have their period of sleep—short, though plainly marked as in the tropics. This time of rest is indicated by the same drooping of the leaves, and other signs which we observe in milder climates.

"The whole country from Norton sound to Point Barrow is one vast moorland, whose level is only interrupted by a few promontories and isolated mountains.

"About Norton sound groves of white spruce trees and *Salix speciosa* are frequent; northward they become less abundant, till in latitude 66° 44′ north, on the banks of the Noatak, *Pinus* [*Abies*] *alba* disappears. *Alnus viridis* extends as far as Kotzebue sound, where, in company with *Salix villosa*, *S. Richardsoni* and *S. speciosa* it forms a low brushwood. With the commencement of the Arctic circle *Alnus viridis* ceases to exist; *Salix speciosa*, *S. Richardsoni*, and *S. villosa* extend their range further, but are only able for a short distance to keep their ground; at Cape Lisburne, in latitude 68° 52′ north, they are in the most favorable localities never higher than two feet, while their crooked growth and numerous abortive leaf-buds indicate their struggle for existence.

"The Esquimaux eat the roots of *Polygonum viviparum* and collect for winter use raspberries, whortleberries, and cranberries, which are frozen so hard as to require an axe to break the mass."

A *Salix speciosa* measured by the botanists of the Herald was found to be but twenty feet high and five inches in diameter, yet the annual rings showed the tree had reached the age of eighty years. [For the above facts in regard to the

mainland north of Norton sound I am indebted to Dr. Seemann, op. citat.—J. T. R.]

Chamisso writes of Kotzebue sound that "the vegetation is much more luxuriant than in St. Lawrence cove," (some distance further to the north on the Siberian side;) "the willows are taller, the grass grows stronger, all the plants are more stout and succulent, while the greater number of species common to the American coast than appear in St. Lawrence cove, indicate a more temperate climate. On the island of St. Lawrence the *Cineraria palustris* grows with a remarkable luxuriance in the well-watered slopes formed at the base of the mounds of ice, while *Betula nana* (dwarf birch) is seen even to the very shores. The plain country of this island is free from snow throughout the summer."

It will be observed that Mr. Seemann draws a line from the mouth of the river Noatak in a northeasterly direction across the country almost to the estuary of Mackenzie river; this he assigns as the northern limit of the woods. This line nearly coincides with the July isotherm of 50°, which temperature may be regarded as a fair growing mean for the species of that region.

Beyond this all plant life is truly Arctic, and comes within the scope of Dr. Hooker's paper on the Distribution of Arctic Plants. The distinguished author just named divides the Arctic circle around the globe into five districts. Going east from Baffin's bay we have, first, the Greenland district; the second one lies between the western coast of Arctic Europe, and extends as far to the east as the river Obi, and includes Nova Zembla and Spitzbergen; the third extends from the Obi river to Behring's strait; the fourth from Behring's strait to the Mackenzie river; and the fifth from Mackenzie river to Baffin's bay. Primarily we are concerned with but three of these divisions: first, the fourth or Arctic Alaskan, and then merely *en passant* with the third and fifth lying on either side of it. From the same paper we learn that the fourth district has of flowering plants 364 species, (the term *species* being used by Hooker in a very wide sense, and all forms which are not clearly marked are regarded merely as boreal varieties of some older species.) Of these 364 (flowering) species, 110 of them are Asiatic and American forms; the third or Arctic Siberian district contains 233 species, and of them but 44 are peculiarly Asiatic and American; the fifth or Arctic eastern American has 379, and of them 110 are peculiarly Asiatic and American. From the above it will be seen that the Arctic Alaskan district has a flora much richer both in specific and *peculiar* specific forms than the Siberian district, but is not quite so rich in species as the fifth or eastern American; the northern limits of vegetation will vary in different longitudes. Rather a rich vegetation clothes the Arctic Alaskan shores, judging from the number of plants collected by Captain Pullen. Herald island, however, in latitude 72° north and longitude 176° west, rewarded Seemann's search with but four species. Eastern Greenland, between 70° and 75° north, gives 150 species. The reason of this disparity in numbers is, in part, found in the following passages:

"The climate of eastern Arctic Asia is marked by excessive mean cold; at the Obi the isotherm of 18° cuts the Arctic circle in its southeast course, and at the eastern extremity of the province the isotherm of 20° cuts the same circle, while the centre part of the district is all north of the isotherm of 9°. The whole of the district is hence far north of the isotherm of 32°, which descends to latitude 52° north in its middle longitude. The extremes of temperature are also very great; the June isotherm of 41° ascending eastward through its western half to the Polar sea, while the September isotherm of 41° descends nearly to 60° north; whence the low autumn temperature must present an almost insuperable obstacle to the ripening of seeds within this segment of the Arctic circle.

"The warming influence of the Atlantic currents being felt no further east than the Obi, and the summer desiccation of the vast Asiatic continent, combine to render the climate of this region one of excessive drought as well as of cold; whence it is in every way most unfavorable to vegetation of all kinds."

Of its 233 species 42 are monoctyledons and 191 are dicotyledons, making a

proportion of 1 to 4.5. In marked contrast to the foregoing is the following from the same author:

"The Arctic circle at Kotzebue sound is crossed by the isotherm of 23°, and at the longitude of the Mackenzie by that of 12° 5′, while the June isotherm of 41° ascends obliquely from southwest to northeast, from the Aleutian islands to the mouth of the Mackenzie, and passes south of this province; the June and September isotherms of 41° and 32° both traverse it obliquely, ascending to the northeast. The vast extent of the Pacific ocean and its warm northerly currents greatly modify the climate of west Arctic America, causing dense fogs to prevail, especially throughout the summer months, while the currents keep the ice to the north of Behring's strait."

In this Arctic Alaskan district we have 76 monoctyledons and 288 dicotyledons, giving a proportion of 1 to 3.7. Dr. Hooker finds in "comparing this flora with that of temperate and Arctic Asia that no less than 320 species are found on the northwestern shores and islands of that continent, or in Siberia, many extending to the Altai and the Himalaya. A comparison with eastern Arctic America shows that 281 species are common to it." Of the 364 species of Arctic Alaskan plants "almost all but the littoral and purely Arctic species are found in west temperate North America or in the Rocky mountains, 26 in the Andes of tropical or sub-tropical America, and 37 in temperate or Antarctic South America."

The above paragraph affords an excellent illustration of the migration southward of northern plants during a period of cold long since past. Whether we clothe this joint explanation of Messrs. Forbes and Darwin with all the dignity of a *theory* logically deduced from other and well-established facts, or reduce it to the rank of a mere *hypothesis*, it still remains the *only philosophical explanation* of these examples of widely-extended distribution along a given meridian.

Dr. Hooker also directs attention to the variety of glumaceæ in the Arctic Alaskan flora: "Of the 138 species of Arctic glumaceæ only 54 are natives of west Arctic America."

I insert here the following letter from Mr. H. M. Bannister, who spent the winter of 1865–'66 at Fort St. Michaels, on Norton Sound. It is to the point and explains itself:

"I am sorry that I can give from personal observation so little information concerning the trees of Russian America. At St. Michaels there were no trees, and the only bushes which rose above the ground were stunted alders and willows. At the head of Norton sound, however, a forest of spruce trees extends nearly to the coast, and occasional trees are seen on the immediate shore. These trees are usually from 20 to 45 feet high and not more than a foot in diameter.

"The drift logs which float on the Kvichpak are sometimes more than two feet in thickness, though the most will not average over a foot or 16 inches. I think it probable the largest trees do not grow where they will be undermined by the river current.

"Mr. Pease reported having seen trees nearly 80 or 100 feet high on the lower Kvichpak. From 1,000 to 1,500 feet of lumber was sawn at Fort St. Michaels during the winter I was there. It made very fair-looking planks and scantling. I think the wood was softer and whiter than that of the Oregon pine. The other trees noticed were poplars and birch; of how many kinds I cannot say. The birch is used by the natives for everything that requires a harder and tougher wood than the spruce, *i. e.*, sled-runners, boat-frames, &c. I have never seen birch there over eight inches in diameter."

In looking over the plants collected by Messrs. Dall, McDonald, and Houle, at Fort Youkon, I have been surprised to see how large a number of them were common on the head-waters of the Mackenzie and the Pelly. Whether Fort Youkon can be considered a point which in their wanderings from more southern localities they might reach, I am not prepared to say; possibly the waters of

the Pelly may have borne them north, and that of the Mackenzie done the same for its banks. Once established on the shores of the latter river a short transit would again place them within reach of the waters of the Porcupine, and this could bear them to and beyond Fort Youkon.

At the same point some plants (few, indeed) have been found that might more naturally have been expected to be confined to the Arctic coast. I do not as yet attempt any explanation of why this place should be a meeting-ground for some few species of more northern and more southern plants.

In how far can our Alaskan possessions raise the grains and vegetables sufficient to support an active population? Vague rumors have reached our ears of this or that hardy vegetable raised at Fort St. Michael or Youkon and afterwards gracing the tables there. Such gardening comes more under the head of possibilities than of daily support. I think we cannot say more yet than that barley and oats will grow at Sitka, and just possibly at Kodiak. Potatoes, radishes, cabbages, cauliflowers, peas, onions, carrots, and turnips may be depended upon as far north as Kodiak, with greater or less certainty. The timber of Alaska is certainly valuable, and much needed on the Pacific coast.

Among the grasses enumerated in our list will be found a number of value as forage plants. The forests once cleared it is certain some of the hardier grasses can be raised, and in considerable quantity. Dr. Kellogg, in his report on the botany of the country, informs us that *(Phleum pratense)* timothy flourishes. As he has not stated in what part, we may perhaps suppose he meant at Sitka, or, possibly, even Kodiak. Several species of bromus are found in various parts of Alaska, and among them may be found perhaps a forage that can be used as a dernier resort. *Poa annua*, or annual spear-grass, grows at Sitka, and affords an early and acceptable pasture; the moist climate of Sitka would, doubtless, suit it well. The Kentucky blue-grass *(Poa pratensis)* is found as far north as Ounalashka and Kotzebue sound; the well-known hardihood of this grass and the readiness with which it is eaten by cattle give it a value. The wood meadow-grass *(Poa nemoralis)* also flourishes at Kotzebue sound, and we may suppose would also at more southern stations; it furnishes good, nutritive food, of which cattle are very fond. Water spear-grass *(Glyceria aquatica)* has been sent us from Sitka, and if cut early makes a hay well relished by cattle. Blue joint-grass *(Calamagrostis Canadensis)* grows as far north as Kotzebue sound, and may be fairly considered a valuable grass. Its yield is often enormous; I have seen it in northern British Columbia growing three feet high, and covering the open grounds there to the exclusion of everything else; its luxuriance was perfectly astonishing. Doubtless some of the sedges and rushes *(Junci)* could be made available in times of scarcity.

I have enumerated within the limits of Alaska 732 species of plants, including the cryptogamia; of these 560 species are phænogams, which represent 57 orders. Of exogens there are 419 species; of endogens, 141 species.

Without going into minute proportions I find the following table gives the relative developement of each of the important orders in comparison with the entire phænogamic flora:

Order.		Genus.	
Compositæ	1-10		
Gramineæ	1-11		
Cyperaceæ	1-14	Carex	32
Cruciferæ	1-17		
Saxifragaceæ	1-17	Saxifraga	24
Ericaceæ	1-17	Vaccinium	9
Rosaceæ	1-19		
Ranunculaceæ	1-20		
Scrophulariaceæ	1-22	Pedicularis	10
		Veronica	6

Order.		Genus.	
Caryophyllaceæ	1–28		
Salicaceæ	1–32	Salix	17
Gentianaceæ	1–40	Gentiana	10
Orchidaceæ	1–40		
Juncaceæ	1–43	Juncus	8
Leguminosæ	1–43		
Onagraceæ	1–47		
Polygonaceæ	1–70		
Coniferæ	1–70		
Umbelliferæ	1–80		
Primulaceæ	1–80		
Borraginaceæ	1–80		
Liliaceæ	1–80		
Betulaceæ	1–93		
Grossulaceæ	1–140		
Caprifoliaceæ	1–140		
Rubiaceæ	1–140		
Labiatæ	1–187		

The area of Alaska, as computed by the United States Coast Survey, is 570,000 square miles, including the islands. Chester county, of the State of Pennsylvania, has but 738 square miles, yet it has just about double the number of indigenous flowering plants that Alaska has. This, however, only implies poverty of specific forms and not necessarily of flora; for we find Alaska covered during its short summer with a luxuriant growth of vegetation, but not of so diversified a character as that of more favored regions.

The proportion of ferns is quite large in Alaska. This is accounted for, doubtless, by the saturated condition of the atmosphere, combined with the deep shade of its more southern forests.

I would here gratefully acknowledge the assistance I have received in preparing this paper from Professor Gray and Dr. George Thurber. To Messrs. James and Mann my thanks are also due; their names appear over their respective communications. Messrs. Bannister, Dall, and Bischoff have each added to the plants hitherto known from Norton sound, Sitka, and the Youkon River district.

I have depended chiefly on the following works: Flora of North America, vols. 1 and 2, Torrey and Gray; Hooker's Flora Boreali Americana; Ledebour's Flora Rossica; Bongard's Vegetation of Sitka; Hooker and Arnott's Botany of Beechey's Voyage; Seemann's Report on the Botany of the Voyage of the Herald; J. D. Hooker on the Distribution of Arctic Plants; and Dr. Lyall's Report on the Botany of Northwestern North America. In the main I have adopted the order of arrangement and the nomenclature of the Flora Rossica. When the complete flora of Alaska is to be published it will be early enough to cease following a guide so satisfactory as Ledebour is, on the whole. However, when a manifest improvement has been suggested by later authorities I have not hesitated to adopt it.

It is hardly necessary to remark that, irrespective of further discoveries, the varied views of different authorities as to what constitutes a species, might sensibly affect the absolute number recorded in this list. So far as the plan upon which it is formed afforded the opportunity, I have adopted the wider view of species as best according with modern philosophic botanical teaching, and as by far the least likely to involve absolute error.

The field which is here merely outlined will offer a rich harvest to the botanist who can devote to the subject the time it demands for thoroughly scientific treatment. The proximity of the two continents and their islands would lead us to think Alaska might prove a good ground for clearing up some doubtful points

concerning the migrations of plants. The well known tendency of Arctic plants to vary almost indefinitely makes the subject important to the botanists interested in settling that vexed question, what is a species and what its formula.

RANUNCULACEÆ.

Thalictrum alpinum, L., Kotzebue sound, and Port Clarence.

Anemone alpina, L., Kotzebue sound.

A. patens, L.; Fort Youkon, Antoine Houle.

A. parviflora, Michx., Kotzebue sound.

A. Richardsoni, Hook., Island of Ounalashka, Kotzebue sound; Youkon river, Dall.

A. narcissiflora, L., is the A. multifida of Hooker and Arnott in Bot. Beechey; *fide* Seemann in Bot. Herald; from Kotzebue sound to Cape Lisburne, and between Point Barrow and Mackenzie river; island of Ounalashka.

Hepatica triloba, Chaix, Sitka.

Ranunculus Pallasii, Schlecht., Kotzebue sound.

R. hyperboreus, Rottb., Norton sound to Wainwright inlet.

R. Purshii, Richards., Kotzebue sound.

R. Lapponicus, L., Kotzebue sound.

R. pygmæus, Wahl., Kotzebue sound.

R. nivalis, R. Br., Kotzebue sound.

R. Eschscholtzii, Schlecht., Kotzebue sound to Cape Lisburne.

R. occidentalis, Nutt., (R. recurvatus, Bongard in Vegetation of Sitka, but *not* of Poir.,) Sitka.

Caltha palustris, L., var. asarifolia, Ounalashka.

C. leptosepala, DC., Sitka.

(Still a third species, C. arctica, R. Br., may yet be added, as it has been found on Richard's island, in the mouth of the Mackenzie river.)

Coptis trifolia, Salisb., Sitka.

C. asplenifolia, Salisb., Sitka.

Aquilegia formosa, Fisch., A. Canadensis, Bong. l. c., Sitka.

Delphinium Menziesii, DC., Kotzebue sound to Cape Lisburne.

Aconitum Napellus, L., var. delphinifolium, Sitka, Kotzebue sound, Chamisso island, Norton sound, and between Point Barrow and Mackenzie river.

NYMPHÆCEÆ.

Nuphar luteum, Smith, Sitka.

PAPAVERACEÆ.

Papaver alpinum, L.; P. nudicaule, Norton sound, H. M. Bannister; Kotzebue sound, and from Point Barrow to Mackenzie river.

FUMARIACEÆ.

Corydalis pauciflora, Pers., Norton sound, H. M. Bannister, Island of St. Lawrence, Bot. Herald.

C. glauca, Pursh., Point Barrow to Mackenzie river, Captain Pullen.

CRUCIFERÆ.

Barbarea vulgaris, R. Br., Sitka and Norton sound.

Arabis hirsuta, Scop., Sitka and Ounalashka.

A. ambigua, DC., Sitka and Ounalashka.

Nasturtium palustre, DC., Eschscholtz bay, Ounalashka; and Youkon river, Dall.

Cardamine Lenensis, Andre, Island of St. Lawrence, Ounalashka and Sitka, *ide* Ledebour, Flora Rossica.

C. pratensis, L., Kotzebue sound, and between Point Barrow and Mackenzie river; Norton sound, H. M. Bannister.

C. hirsuta, L., Ounalashka and Sitka.

C. purpurea, Cham., Kotzebue sound, Wainwright inlet, and Island of Ounalashka.

C. digitata, Richards., (possibly only a form of C. pratensis; *fide* J. D. Hooker in "Outlines of the Distribution of Arctic Plants,") Wainwright inlet, between Point Barrow and Mackenzie river; Island of St. Lawrence.

Alyssum hyperboreum, L.—A doubtful native of North America. Ledebour in Flora Rossica simply tells us (on the authority of Steller and Krasch) that it is "in ora occidentali Americæ borealis."

Parrya macrocarpa, R. Br., Kotzebue sound, Cape Lisburne, between Point Barrow and Mackenzie river, and Island of St. Lawrence.

Draba algida, DC., Island of St. Lawrence.

D. alpina, L., Kotzebue sound.

D. glacialis, Adams, Cape Lisburne, Assistance bay, and Garry island.

D. stellata, Jacq., var. hebecarpa, Kotzebue sound, Ounalashka; and *fide* Ledebour, Flora Rossica in Island of St. Lawrence.

D. hirta, L., Kotzebue sound.

D. incana, L., Garry, St. Lawrence, and Ounalashka islands.

D. gracilis, Ledeb., Ounalashka.

D. borealis, DC., islands of Ounalashka and St. Lawrence. Perhaps only a leafy form of D. incana, according to J. D. Hooker.

D. Unalaschkiana, DC., "an var. D. borealis?" Ledebour, op. citat., Ounalashka.

D. stenoloba, Ledeb., Island of Ounalashka.

D. muricella, Wahl.; D. nivalis, Liljebl., Wainwright inlet.

D. grandis, Langsdorff, in DC., Systema, vol. ii, p. 355; var. siliquosa, Cochlearia grandiflora, DC., Systema, vol. ii, p. 368; Cochlearia spathulata, Schlecht. See Torrey and Gray, Flora of North America, vol. i, p. 110. Draba grandis is figured in Del. Icon., 2, tab. 47. One specimen differs from the figure mainly in having longer and less turgid pods, and the leaves being rather more entire; but it is without doubt the same plant. A foot-note in Linnæa, vol. ii, p. 27, throws much light on its otherwise rather complicated synonymy. This plant had not been found in Sitka previous to its recent discovery there by Mr. Bischoff, the nearest known approach hitherto being Ounalashka.

Cochlearia fenestrata, R. Br., Norton sound to Point Barrow and Assistance bay.

C. oblongifolia, DC., Sitka, Kotzebue sound, Wainwright inlet, and between Point Barrow and Mackenzie river; also found at Norton sound by Mr. Bannister.

C. Anglica, L., Kotzebue sound and Assistance bay.

Tetrapoma pyriforme, Seemann, tab. 2, Botany of Voyage of the Herald. Collected both in the voyage of the Herald and later by Mr. Bannister at Fort St. Michaels, at Norton sound. Seemann regards it as introduced from Asia by the Russians. He is probably correct, as it has not been found elsewhere in North America.

Hesperis Pallasii, T. and G., Kotzebue sound and Cape Lisburne.

Sisymbrium Sophia, L., var. sophioides, Kotzebue sound, and between Point Barrow and Mackenzie river.

Erysimum lanceolatum, R. Br.; Arctic coast, Pullen.

Eutrema Edwardsii, R. Br., island of St. Lawrence.

Aphragmus Eschscholtzianus, Andrz., Ounalashka.

Hutchinsia calycina, Desv., Kotzebue sound and Cape Kruzenstern

VIOLACEÆ.

Viola biflora, L.; var. Sitchensis, Regel; V. Canadensis, in Bongard's Vegetation of Sitka, where it is also cited as V. Scouleri, Dougl. The Sitkan plant is certainly very variable; one form is without doubt V. glabella, Nutt; yet after carefully comparing a full suite of specimens I think Regel has correctly assigned it to V. biflora, L.

V. blanda, ?, Kotzebue sound; Botany Beechey's Voyage.

V. Langsdorffii, Fisch.; Kodiak and Ounalashka, Kellogg.

DROSERACEÆ.

Drosera rotundifolia, L.; Sitka.

Parnassia palustris, L.; Norton sound, H. M. Bannister; Fort Youkon, W. H. Dall.

P. Kotzebuei, Cham.; Port Clarence to Cape Lisburne, Bot. Herald.

CARYOPHYLLACEÆ.

Dianthus repens, Willd.; Norton sound, Kotzebue sound, Cape Lisburne, and Youkon River banks.

Silene acaulis, L.; Kotzebue sound, Cape Lisburne, and between Point Barrow and Mackenzie river.

Melandryum apetalum, Fenzl, Kotzebue sound and on the northern coast; noted by Seemann as being quite common throughout western Esquimaux land.

Spergula saginoides, L., Sitka, Ounalashka, and Kotzebue sound.

S. rubra, T. and G., Sitka.

S. arvensis, L.; Sitka, Ferd. Bischoff.

Arenaria verna, L., (var. hirta,) along the western shore of northern Alaska.

A. arctica, Fenzl, Kotzebue sound to Cape Lisburne.

A. macrocarpa, Fenzl, island of St. Lawrence and northwest coast.

Honkeneya peploides, Ehr., northern shores.

H. peploides, var. oblongifolia, Sitka and Kotzebue sound.

Merkia physodes, Fisch., Norton sound to Point Barrow.

Moehringia lateriflora, Fenzl, Sitka and Ounalashka; Fort Youkon, Rev. McDonald.

Stellaria media, Smith, Sitka and Ounalashka.

S. borealis, Bigelow, Sitka and Ounalashka.

S. borealis, var. crispa, Sitka and Ounalashka.

S. crassifolia, Ehr.; Sitka, Mertens.

S. humifusa, Rottbl., Sitka; Norton sound, H. M. Bannister; Kotzebue sound.

S. longifolia, Muhl., Sitka and Kotzebue sound.

S. longipes, Goldie; Kotzebue sound and Youkon river, W. H. Dall.

Cerastium vulgatum, L.; C. alpinum, in Bongard's Vegetation of Sitka.

C. vulgatum, L.; var. grandiflorum, Ledeb., in Flora Rossica; Norton sound, H. M. Bannister.

C. vulgatum, L., var. Behringianum, Ledeb., Flora Rossica; Kotzebue sound to Cape Lisburne.

I am quite unable to separate by clear lines the numberless forms of C. vulgatum. Almost impossible extremes graduate into each other.

LINACEÆ.

Linum perenne, L.; Fort Youkon, Antoine Houle.

GERANIACEÆ.

Geranium erianthum, DC., Sitka and Ounalashka.

LEGUMINOSÆ.

Lupinus perennis, L., Kotzebue sound.

L. Nootkatensis, Donn, Ounalashka; Fort Youkon, Antoine Houle.

Trifolium repens, L., Sitka; *fide* Dr. A. Kellogg, in manuscript report.

Astragalus frigidus, Gray, Phaca frigidus, L., Kotzebue sound.

A. alpinus, L., Kotzebue sound to Point Barrow; and Fort Youkon, W. H. Dall.

A. polaris, Benth.; rediscovered by Seemann at Eschscholtz bay, in Kotzebue sound, during the voyage of the Herald. See Hooker, J. D., on Distribution of Arctic Plants.

A. hypoglottis, L.; Point Barrow and eastward, Pullen; Fort Youkon, W. H. Dall.

Oxytropis campestris, D. C., including O. borealis, DC., Kotzebue sound.

O. Uralensis, L., Kotzebue sound and west coast of Alaska.

Vicia gigantea, Hook., V. Americana, Muhl.; Sitka, Kellogg; Arctic coast, Pullen.

Lathyrus maritimus, Bigel., Sitka and western coast of Alaska.

Hedysarum boreale, Nutt, Kotzebue sound and Cape Lisburne.

H. Mackenzii, Richards., Youkon river, 50 miles west of Fort Youkon; "sweetish root, eaten by the Indians,—Dall.

ROSACEÆ.

Spiræa betulæfolia, Pall., Kotzebue sound.

S. Aruncus, L., Sitka.

S. salicifolia, L.; Point Barrow to Mackenzie river, Pullen.

S. pectinata, T. and G., Sitka and about Behring's strait.

Dryas octopetala, L., Kotzebue sound to Port Clarence and northern shore. I cannot do otherwise than unite D. integrifolia, Vahl., with this species; J. D. Hooker has already done so in his paper above quoted.

Geum macrophyllum, Willd., Sitka and Ounalashka.

G. calthifolium, Smith, Ounalashka and Sitka.

G. glaciale, Adams, Cape Lisburne and Kotzebue sound; also found on northern shore west of Mackenzie river.

G. Rossii, Seringe Ounalashka.

Sanguisorba Canadensis, L., banks of Buckland river, Ounalashka, Sitka, Fort Youkon, and Youkon River banks.

Sibbaldia procumbens, L., Ounalashka.

Potentilla Norvegica, L.; Sitka and Point Barrow to Mackenzie river, Pullen.

P. Pennsylvanica, L., Kotzebue sound.

P. Anserina, L.; Sitka, Kotzebue sound, Point Barrow, northern coast; Fort Youkon, Mr. Dall.

P. nana, Lehm., Kotzebue sound.

P. emarginata, Pursh, Kotzebue sound, and between Point Barrow and Mackenzie river.

P. nivea, L., Kotzebue sound and coast west of Cape Bathurst; *fide* Botany of the Herald.

P. villosa, Pall., Kotzebue sound, Ounalashka, and Sitka.

P. biflora, Lehm., Kotzebue sound and Cape Lisburne.

P. fruticosa, L., Kotzebue sound and banks of Buckland river.

P. palustris, Scop., Sitka and island of St. Lawrence.

Rubus spectabilis, Pursh, Sitka, Kodiak, and Cape St. Elias.

R. arcticus, L., Kotzebue sound.

R. pedatus, Smith, Sitka.

R. Chamæmorus, L., Sitka and northern and western coast of Alaska.

R. Nutkanus, Moç.; Sitka, Ferd. Bischoff.

Rosa cinnamomea, L.; Point Barrow to Mackenzie river, Pullen; Fort Youkon, Dall.

Pyrus rivularis, Dougl., Sitka.

P. sambucifolia, Cham. and Schlecht., Sitka.

ONAGRACEÆ.

Epilobium angustifolium, L., Sitka, Ounalashka, northern and western shores of Alaska, Fort Youkon, and banks of Youkon river.

E. latifolium, L., Norton sound to Point Barrow, Sitka, and Ounalashka.

E. luteum, Pursh, Sitka and Ounalashka.

E. palustre, L., Kotzebue sound; *fide* Ledebour, in Flora Rossica.

E. tetragonum, L., given as a native of this region.

E. roseum, Schreb., Sitka.

E. alpinum, L., Sitka.

E. affine, Bongard, Sitka.

Circæa alpina, L., Sitka.

Hippuris vulgaris, L., Sitka and Bay of Good Hope.

H. montana, Ledeb., Ounalashka.

H. maritima, Hellen., Kotzebue sound and delta of river Buckland.

PORTULACACEÆ.

Claytonia Virginica, L., Kotzebue sound.

C. sarmentosa, C. A. Meyer, Cape Lisburne and Kotzebue sound.

C. flagellaris, Bong., Sitka.

C. Sibirica, L., Sitka and Cape St. Elias.

C. Chamissonis, Eschscholtz, (C. aquatica, Nutt. in Flora North America, Torrey and Gray; *fide* Ledebour,) Ounalashka.

Montia fontana, L., Sitka, Ounalashka, Norton sound, and Kotzebue sound.

CRASSULACEÆ.

Sedum Rhodiola, DC., Norton and Kotzebue sounds.

GROSSULACEÆ.

Ribes rubrum, L., Port Clarence and Kotzebue sound; Youkon river, Dall

R. Hudsonianum, Richards.; Youkon river, Dall.

R. laxiflorum, Pursh, Cape St. Elias and Sitka.

R. bracteosum, Dougl., Sitka.

R. lacustre, Pursh; Point Barrow to Mackenzie river, Pullen.

SAXIFRAGACEÆ.

Saxifraga oppositifolia, L., Ounalashka, Cape Lisburne, Kotzebue sound, and northern coast.

S. bronchialis, L., Kotzebue sound, Wainwright inlet, and Ounalashka.

S. nitida, Schreb., Ounalashka; *fide* Ledebour, Flora Rossica.

S. Eschscholtzii, Sternb., Cape Lisburne and Kotzebue sound.

S. flagellaris, Willd., Cape Lisburne, Kotzebue sound, and Assistance bay.

S. Hirculus, L., Norton sound to Point Barrow, and on northern coast.

S. tricuspidata, Retz, Kotzebue sound and Ounalashka; Fort Youkon, Mr. Dall.

S. serpyllifolia, Pursh, Cape Lisburne, Ounalashka, and Island of St. Lawrence.

S. leucanthemifolia, Lap., (S. stellaris, L., var. Brunoniana, Bongard, Veg. Sitka,) Sitka and Cape Prince of Wales.

S. Davurica, Pall., (Seemann has united with this species S. flabellifolia, and apparently on good grounds,) Cape Lisburne, Kotzebue sound and Ounalashka.

S. nivalis, L., Ounalashka, Cape Lisburne, and other stations on the coast.

S. cernua, L., Point Barrow to Mackenzie river, Pullen.

S. hieracifolia, W. and K., island of St. Lawrence and Kotzebue sound.

S. Nelsoniana, Don, (not of Hooker and Arnott, in botany of Beechey's Voyage,) Norton sound, H. M. Bannister.

S. spicata, Don, Sledge island and Cape Prince of Wales.

S. punctata, L., S. æstivalis, Fischer, Sitka, Ounalashka, and Kotzebue sound.

S. arguta, Don, "northwest coast." Where?

S. nudicaulis, Don, between Norton and Kotzebue sounds; *fide* Ledebour, Fl. Ross.

S. heteranthera, Hooker; S. Mertensiana, Bong., Veg., Sitka; *fide* Ledebour, S. æstivalis, var. T. and G., Sitka.

S. exilis, Steph., bays of Schischmareff and Eschscholtz; most likely, as suggested by J. D. Hooker, only a weedy state of S. cernua, L.

S. Sibirica, L., Kotzebue sound.

S. rivularis, L., Kotzebue sound.

S. cæspitosa, L., Kotzebue sound.

S. exarata, Vill., Ounalashka, and Kotzebue sound.

S. sileniflora, Sternb., Kotzebue sound, and Ounalashka.

S. androsacea, L., is hardly likely to be identical with the plant said by Pursh to inhabit the northwest coast; I do not therefore include it in this list.

Boykinia Richardsonii, Saxifraga Richardsonii, Hook.; S. Nelsoniana, Hook. and Arnott, in Botany of Beechey's Voyage, tab. 29.

Leptarrhena pyrifolia, R. Br., Ounalashka and Cape Prince of Wales?

Chrysosplenium alternifolium, L., Kotzebue sound to Cape Lisburne.

Tellima grandiflora, Dougl., Sitka and the islands adjacent the coast.

Tiarella trifoliata, L., Sitka and Alaskan coast.

Heuchera glabra, Willd.; H. divaricata, Fisch., Sitka.

UMBELLIFERÆ.

Bupleurum ranunculoides, L., Port Clarence to Cape Lisburne; Norton sound, H. M. Bannister.

Ligusticum Scoticum, L., Sitka, Kodiak, Kotzebue sound, and Norton sound.

Conioselinum Fischeri, Wimm. Grab., Sitka, Ounalashka, Kotzebue sound, and Arctic coast.

Heracleum lanatum, Michx., Sitka.

Osmorrhiza nuda, Torr.; O. brevistylus, Bongard, Vegetation of Sitka, Ounalashka, and Sitka.

Archangelica officinalis, Hoffm., Ounalashka and Kotzebue sound; Sitka, Kellogg.

A. Gmelini, DC., Sitka, Ounalashka, and Kotzebue.

ARALIACEÆ.

Panax horridum, Smith, Sitka and Kodiak.

Adoxa Moschatellina, L., Russian America, *fide* Ledebour; what part?

CORNACEÆ.

Cornus Suecica, L., common on western coast of Alaska.

C. Unalaschkensis, Ledebour, Ounalashka.

C. Canadensis, L., Sitka.

C. stolonifera, Michx.; Fort Youkon, Dall.

CAPRIFOLIACEÆ.

Sambucus pubens, Michx., Sitka.

Viburnum acerifolium, L.; Fort Youkon, Dall.

V. pauciflorum, Pylaie; V. acerifolium, Bongard's Veg. Sitka. The stipuliform appendages appear to be the only constant difference between these two species in my specimens. They are quite variable in length of stamens and shape of corolla.

Linnæa borealis, Gronov., Norton and Kotzebue sounds, and Sitka and Ounalashka.

RUBIACEÆ.

Galium trifidum, L., Ounalashka and Sitka.

G. boreale, L.; G. rubioides, Hook. and Arnott, Bot. Beechey, *fide* Seemann, Kotzebue sound, River Buckland, Fort Youkon, and banks of the Youkon river.

G. triflorum, Michx., Sitka and Ounalashka.

G. aparine, L., Sitka and Ounalashka.

VALERIANACEÆ.

Valeriana dioica, L., Norton sound.

V. capitata, Willd., Kotzebue sound to Cape Lisburne, Sitka; Point Barrow to Mackenzie river, Pullen.

COMPOSITÆ.

Nardosmia frigida, Hook., includes N. corymbosa, Hook.; Ounalashka, Norton sound; and the northern coast, Pullen.

Aster multiflorus, Ait. Perhaps we may include under this A. ramulosis, Lindl., and A. falcatus, Lindl. If this be done, we have one polymorphic species, ranging from Georgia to Point Barrow and Mackenzie river, and from Massachusetts to the Rocky mountains; northern coast, Pullen.

A. peregrinus, Pursh, Ounalashka and Norfolk sound.

A. foliaceus, Lindl.; Ounalashka, Fischer.

A. salsuginosus, Richards., Sitka, Ounalashka, and Kotzebue sound.

A. alpinus, L., Ounalashka, 2,000 feet above the sea, *fide* Kellogg.

A. Sibiricus, L.; including, after J. D. Hooker and Fries, A. montanus, Richards, and A. Richardsonii, Spr.; Kotzebue sound, Ounalashka, and Point Barrow, Pullen.

Erigeron uniflorum, L. Following Fries, I include under this species E. pulchellum, DC., as a variety. There is unquestionably good ground for the union; Ounalashka and Cape Lisburne.

E. glabellum, Nutt.; Wainwright inlet to Mackenzie river; var. asperum, Fort Youkon, Dall., Rev. McDonald, and Antoine Houle.

Solidago Virga-aurea, L., Ounalashka to Kotzebue sound, Cape Lisburne, and on northern coast; var. multiradiata, Fort Youkon, Dall.

S. confertiflora, DC., Ounalashka and Cape Mulgrave; Kodiak, Dr. A. Kellogg.

Ptarmica borealis, DC., Sitka.

P. Sibirica, Ounalashka and Eschscholtz bay.

P. speciosa, DC.; given by Ledebour on the authority of J. G. Gmelin as a native of this region.

Achillea Millefolium, L., Norton sound, Ounalashka, Sitka, and Fort Youkon.

Leucanthemum integrifolium, DC., Kotzebue sound, island of St. Lawrence, and from Point Barrow to Mackenzie river, Pullen.

L. arcticum, DC., Norton sound to Washington inlet.

Matricaria discoidea, DC., Sitka and Ounalashka.

M. inodora, L., Kotzebue sound. M. inodora var. eligulata was also collected both by Bannister and Seemann at Norton sound. This is not only destitute of rays, but is also stouter, and may, as Mr. Seemann suggests, be entitled to specific rank.

Tanacetum Kotzebuense, Bess., Cape Espenberg, *fide* Ledebour ex Escholtz.

T. Huronense, Nutt, Fort Youkon, Dall.

Artemisia borealis, Pallas, Kotzebue sound and Arctic coast, and what seems to be a variety with glomerate, almost capitate, inflorescence, from Sitka.

A vulgaris, L.; var. Tilesii, Fort St. Michaels and western and northern coasts.

A. glomerata, Ledeb.? Kotzebue sound.

A. androsacea, Seem,. Bot. Herald, tab. 6; A. glomerata of Hooker and Arnott, Bot. Beechey, but not of Ledebour, *fide* Seemann. This, it is thought by Dr. Hooker, may prove "an arctic tufted variety of some better known plant."

A. globularia, Cham., Ounalashka and island of St. Lawrence.

A. arctica, Less., Cape Lisburne and Point Hope, and possibly Sitka.

A. Chamissonis, Bess. Seemann states that though A. arctica and A. Chamissonis are by some authors united, they may at once be distinguished by their different habits.

A. Absinthium, L. Given by Ledebour, (Flora Rossica,) on the authority of J. G. Gmelin, as a doubtful native of Russian America.

Gnaphalium sylvaticum, L., Russian America, *fide* Ledebour ex J. G. Gmelin.

Antennaria alpina, Gaert.; including A., monocephala, DC., Kotzebue sound, island of St. Lawrence and Ounalashka.

A. dioica, Gaert., islands adjacent to the American coast, Ledebour ex J. G. Gmelin.

A. margaritacea, R. Br., Sitka, (Ferd. Bischoff,) and Ounalashka.

Arnica angustifolia, Vahl, Kotzebue sound and Fort Youkon, Dall.

A. Chamissonis, Less., Ounalashka.

A. obtusifolia, Less., Ounalashka.

A. Uunalaschkensis, Less., Ounalashka.

A. latifolia, Bong., Sitka.

Senecio resedifolius, Less., Cape Lisburne and Kotzebue sound.

S. frigidus, Less., Kotzebue sound, Cape Lisburne and island of St. Lawrence.

S. triangularis, Hooker, Sitka, Eschscholtz.

S. Pseudo-arnica, Less., common on western shore of Alaska; also on Chamisso island.

S. aureus, L., Fort Youkon, Antoine Houle.

S. lugens, Richards. Kotzebue sound and Cape of Good Hope; Fort Youkon, Mr. Dall.

S. palustris, DC., Norton sound, Kotzebue sound, Wainwright inlet, and on the northern shore.

S. Hookeri, T. and G., Kotzebue sound.

Saussurea alpina, L., Kotzebue sound. I here include S. monticola, which Pullen found on the northern shore from Point Barrow to Mackenzie river.

S. subsinuata, Ledeb., Kotzebue sound, Bot. Herald, tab. 7.

Taraxacum Dens Leonis, Desf., Kotzebue sound to Point Hope and northern coast, Ounalashka; var. ceratophorum, Ounalashka and Norton sound.

T. palustre, DC., Kotzebue sound.

T. lyratum, DC., Ounalashka.

Mulgedium pulchellum, Nutt.; Point Barrow to Mackenzie river, Pullen.

Nabalus alatus, Hooker, Ounalashka and Sitka.

Apargidium boreale, T. and G., Sitka.

Hieracium triste, Willd., Ounalashka and Norfolk sound.

CAMPANULACEÆ.

Campanula dasyantha, M. a Bieb., Ounalashka and Cape Prince of Wales.
C. rotundifolia, L., C. heterodoxa, Vest., Sitka.
C. uniflora, L., Kotzebue sound, Cape Lisburne, and Ounalashka.
C. lasiocarpa, Cham., Kotzebue sound and Ounalashka.

ERICACEÆ.

Vaccinium Vitis-Idæa, L., Ounalashka, St. Lawrence, Sitka; from Norton sound to Point Barrow and on the northern coast.
V. myrtilloides, Hooker; Sitka, Ferd. Bischoff.
V. Myrtillus, L.; Sitka, Ferd. Bischoff.
V. Chamissonis, Bong., Sitka and Ounalashka.
V. ovalifolium, Smith; Sitka, Ferd. Bischoff.
V. parvifolium, Smith; Sitka, Ferd. Bischoff.
V. salicinum, Cham. and Schlecht., Ounalashka.
V. cæspitosum, Michx., Sitka.
V. uliginosum, L., Sitka, Ounalashka, Kotzebue sound, and the northern coast.
Oxycoccus vulgaris, Pursh, Sitka, Ounalashka, and Kotzebue sound.
Arctostaphylos alpina, Spreng., Ounalashka; Norton sound to Point Barrow; also on the Arctic coast.
A. Uva-ursi, Spreng., Ounalashka and Cape Prince of Wales, Arctic coast, Pullen.
Andromeda polifolia, L., Sitka and Kotzebue sound.
Cassandra calyculata, Don, Kotzebue sound.
Cassiope lycopodioides, Don, Ounalashka.
C. tetragona, Don, Island of St. Lawrence, Kotzebue sound to Point Barrow, and on the Arctic coast.
C. Mertensiana, Don, Sitka.
C. Stelleriana, DC., Sitka.
Phyllodoce Pallasiana, Don, Sitka and Ounalashka.
Menziesia ferruginea, Smith, Sitka, and Ounalashka.
Loiseleuria procumbens, Desv., Cape Lisburne and islands of Ounalashka and Chamisso.
Rhododendron Lapponicum, Wahl., Port Clarence.
R. Kamtschaticum, Pall., Ounalashka.
Kalmia glauca, Ait., Sitka.
Ledum latifolium, Ait., Sitka.
L. palustre, L., Norton sound to Point Barrow and northern coast. This and the preceding species should probably be united.
Cladothamnus pyrolæflorus, Bong., Sitka.
Pyrola rotundifolia, L., Ounalashka, Kotzebue sound, and northern coast.
P. minor, L., Ounalashka.
P. secunda, L., Sitka and Kotzebue sound.
Moneses grandiflora, Salisb., Sitka.

LENTIBULACEÆ.

Pinguicula vulgaris, L., Sitka.
P. microceras, Willd., Ounalashka.
P. macroceras, Cham., Ounalashka.
P. villosa, L., islands of Chamisso and Ounalashka; also, Norton sound, H. M. Bannister.

PRIMULACEÆ.

Primula nivalis, Pall., islands of Ounalashka and St. Lawrence, and Kotzebue sound.

P. stricta, Hornem., after J. D. Hooker, l. c., I include under this species P. Hornemanniana and P. Mistassinica, both of C. and S. and of Michx., Kotzebue sound.

Androsace Chamæjasme, Willd., Kotzebue sound to Wainwright inlet.

A. septentrionalis, L., Kotzebue sound and Chamisso island, Fort Youkon, Antoine Houle.

A. villosa is stated by Ledebour to have been found at Kotzebue sound, in Beechey's Voyage. I see no record of it in Hooker and Arnott's list of plants collected there. Possibly it may be an oversight on Ledebour's part.

Dodecatheon Meadia, L., Sitka, Kotzebue sound, and Cape Lisburne. I can find no valid grounds for keeping up the distinction between D. Meadia, D. integrifolium, and D. frigidum. The last is probably the most marked variety of the number; but after a careful comparison of the forms comprising the genus I think it safest to regard them as varieties of a widely distributed polymorphic species.

Glaux maritima, L., Sitka.

Trientalis Europæa, L., Sitka, Norton sound; H. M. Bannister.

GENTIANACEÆ.

Gentiana Amarella, L., Sitka.

G. acuta, Michx., Ounalashka.

G. tenella, Rottb., Kotzebue sound.

G. detonsa, Fries; Point Barrow to Mackenzie river, Pullen; Fort Youkon, Antoine Houle.

G. propinqua, Richards.; G. Rurickiana, Kotzebue sound, Port Clarence, and Norton sound, H. M. Bannister.

G. Aleutica, Cham., Ounalashka.

G. prostrata, Hænke, Ounalashka and Kotzebue sound.

G. glauca, Pall., Kotzebue sound and Wainwright inlet.

G. platypetala, Griesb.; Sitka, Eschscholtz.

G. Douglasiana, Bong., Sitka.

Pleurogyne rotata, Griesb., Kotzebue sound, river Buckland and Arctic coast.

Swertia perennis, L., Kodiak, Dr. A. Kellogg; S. perennis, L., var. obtusa, Kodiak, Dr. A. Kellogg.

Villarsia Crista-galli, Griesb., Sitka.

Menyanthes trifoliata, L., Ounalashka and Sitka.

POLEMONIACEÆ.

Phlox Sibirica, L., Kotzebue sound.

Polemonium cæruleum, L., Norton sound to Point Barrow; islands of St. George, Ounalashka, and Chamisso; Fort Youkon, Dall. I recognize but two species of this genus belonging to northern North America—the one, P. reptans, L., which is well marked, and the other P. cæruleum, L., as made up of all the others. Numerous as the forms and wide as the extremes of the latter aggregate species are, they can easily be connected. Even P. pulchellum, Bunge, which is perhaps the best marked variety, shades off by insensible gradations into the others.

Diapensia Lapponica, L., island of St. Lawrence.

BORRAGINACEÆ.

Mertensia maritima, Don, Sitka, Norton sound to Point Barrow and Cape Bathurst.

M. paniculata, Don, M. pilosa, DC.; Kotzebue sound; Fort Youkon, Antoine Houle and Mr. Dall.

M. Sibirica, Don; M. denticulata, Don, Kotzebue sound.

Myosotis sylvatica, Hoffm., Cape Lisburne and Arctic coast.

Echinospermum Redowskii, Lehm.? Fort Youkon, Rev. McDonald.

Eritrichium villosum, Bunge. I include here, after J. D. Hooker, l. c., E. aretioides A. DC., which form is found at Cape Lisburne and island of St. Lawrence, Tab. viii, Bot. Herald.

E. plebejum, Alph. DC., Ounalashka.

HYDROPHYLLACEÆ.

Romanzoffia Unalaschkensis, Cham., Ounalashka.

R. Sitchensis, Cham., Sitka.

SCROPHULARIACEÆ.

Pentstemon frutescens, Lamb., Ounalashka. Not found since Pallas is said to have discovered it in Kamtschatka and in the island of Ounalashka.

Mimulus luteus, L., M. guttatus, DC., Cape St. Elias, Ounalashka, Kodiak, and Sitka.

Veronica Anagallis, L., Sitka.

V. Americana, Schweinitz, Sitka, Ferd. Bischoff.

V. Beccabunga, L., Ounalashka.

V. Stelleri, Pall., Ounalashka.

V. alpina, L., Sitka and Ounalashka.

V. serpyllifolia, L., Sitka and Ounalashka.

Castilleja pallida, Kunth, Sitka, Kotzebue sound, Chamisso island and Arctic coast; Fort Youkon, Dall. J. D. Hooker has included, and I think justly, under this species C. septentrionalis, Lindl. Professor Gray has also united them, in the last edition of his Manual of Botany; also, in his revision of the genus, (see Am. Jour. Sci., second series, vol. xxxiv, p. 44.)

C. parviflora, Bong., Sitka. "This is apparently the commonest species and of widest range west of the Rocky mountains, extending from Russian America to southern California."—Gray, l. c.

Rhinanthus Crista-galli, L., Ounalashka.

Pedicularis verticillata, L., Sitka and the islands generally; also, Kotzebue sound.

P. Chamissonis, Stev., Ounalashka.

P. pedicellata, Bunge, P. nasuta, Bong., in Veg. Sitka, non M. a Bieb. *fide* Ledeb. Fl. Rossica, Sitka.

P. subnuda, Benth., Sitka, Barclay.

P. palustris, L., Arctic America, at Bay of Good Hope, *fide* Ledebour in Fl. Ross.

P. euphrasioides, Steph., Norton and Kotzebue sounds; islands of Chamisso and Kodiak.

P. Sudetica, L., Cape Lisburne, Kotzebue sound, Arctic coast and island of St. Lawrence. J. D. Hooker suggests uniting with this P. Langsdorffii. On his authority I admit the reduction.

P. hirsuta, L., including here P. lanata, Willd., as done by Bentham, *fide* J. D. Hooker; islands of St. George and St. Lawrence, Kotzebue sound and Arctic coast.

P. versicolor, Wahlenb., Kotzebue sound and island of St. Lawrence.

P. capitata, Adams, Kotzebue sound, Arctic coast and Ounalashka.

OROBANCHACEÆ.

Boschniakia glabra, C. A. Meyer, Sitka and Kotzebue sound.

SELAGINACEÆ.

Gymnandra Gmelini, Cham. et Schlecht., Ounalashka, St. Lawrence island?

G. Stelleri, Cham. et Schlecht., Kotzebue sound, island of St. Lawrence?

LABIATÆ.

Dracocephalum paviflorum, L., Fort Youkon, Antoine Houle.
Brunella vulgaris, L., Sitka and Ounalashka.
Galeopsis Tetrahit l.; Sitka, Kellogg. Introduced, most likely. It is, however, found in Kamtschatka, but not being known to exist elsewhere between these two points we can hardly account for its presence in Sitka by strictly natural agencies.

PLUMBAGINACEÆ.

Statice Armeria, L., Ounalashka, Kotzebue sound, and northern coast.

PLANTAGINACEÆ.

Plantago major, L., Sitka, banks of Youkon river, Dall.
P. macrocarpa, Cham. et Schlecht., Sitka and Ounalashka.
P. maritima, L., Sitka and Ounalashka.
P. media, L., Russian America, *fide* J. G. Gmelin. What part?

POLYGONACEÆ.

Oxyria reniformis, Hook., islands of Sitka, Ounalashka and St. Lawrence, Kotzebue sound, Cape Lisburne and Arctic coast.
Rumex salicifolius, Weinm., Sitka.
R. Acetosa, L., Kotzebue sound.
R. domesticus, Hartm., Sitka, Ounalashka, and Kotzebue sound to Wainwright inlet.
Polygonum Bistorta, L., Kotzebue sound to Point Barrow and northern coast.
P. viviparum, L., Sitka, Ounalashka, and along the coast generally.
P. polymorphum, Ledeb., var. lapathifolium, Ledeb., Kotzebue sound. P. alpinum, Hook. et Arnott in Beechey's voyage, *fide* Ledebour, Kotzebue sound. Professor Gray informs me that one of the doubtful forms I have sent him from Mr. Dall's Fort Youkon collection is exactly P. alpinum as found at Kotzebue sound. It has an exserted broadly winged achenium. The lower leaves, however, are not so reduced as in P. tripterocarpum, the description of which I append in a foot-note. I have, however, some older fruit of it than he had, and am led to think it may yet prove P. tripterocarpum.—Gray. The description of which I insert below.*
P. aviculare, L., Sitka.

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* "Polygonum tripterocarpum, Gray, n. sp., caule erecto vel assurgente simplici vel parce ramoso, longitudinaliter striato glabro vel ad nodos deorsumque breviter retrorso pubescente; foliis (inferioribus ad ochream reductis) patentibus lineari-lanceolatis acuminatis basi angustatis breviter petiolatis glabris vel subtus ad nervum puberulis margine ciliatis undulatisque inferioribus supra basim tertia parte superioribus imæ basi insertis; ochreis laxis nervoso—striatis rufis glabris vel basi pubescentibus; panicula angusta foliata; bracteis latis 1–2 flores; pedicellis exsertis florum æquantibus supra medium articulatis sepalis ovalibus vel obovatis obtusis; staminibus ovarii dimidium æquantibus; achenio exserto calyce 3–4—plo longiore obovato late trialato stylis 3 recurvatis coronato stigmatibus capitatis; semine (immaturo) valde stipitato."
Coal bay, J. Small; Arakamtchetchene island, C. Wright. The specimens from two or three rather remote localities are 8–15 inches high, erect or slightly assurgent at the base; the short lower joints two or three times as long as the rather inflated leafless sheaths. Some of the specimens are clothed at and below the nodes of the middle of the stem with a more or less dense retrorse pubescence, while the lower and upper parts are nearly or quite smooth. The points, however, in which they seem to differ most from P. polymorphum, P. divaricatum, and other allied species, are in their conspicuously exserted and broadly winged achenium as well as in their rather strict, nearly unbranched habit." Professor Gray's MSS. (Mr. Dall found the same species at Plover bay, and if the form P. polymorphum var. lapathifolium does not prove P. tripterocarpum it is likely the latter may yet be found on the American side.)

EMPETRACEÆ.

Empetrum nigrum, L., Sitka, St. Lawrence, Ounalashka, Norton sound to Point Barrow and Arctic coast.

SALICACEÆ.†

Salix myrtilloides, L., Kotzebue sound.
S. Lapponum, L., Kotzebue sound.
S. glauca, L., Cape Espenberg and Chamisso island.
S. arctica, Pall., Ounalashka and Kotzebue sound.
S. myrsinites, L., island of St. Lawrence, *fide* Ledebour.
S. ovalifolia, Trautvett.; S. Uva-ursi, Seemann, Bot. Herald, (*fide* Anderson,) Kotzebue sound, Cape Espenberg, and Island of Ounalashka.
S. rhamnifolia, (Pall?) Ounalashka.
S. glacialis, Anders., between Cape Barrow and Mackenzie river, "Captain Pullen."
S. reticulata, L., Ounalashka, Kotzebue sound, Cape Lisburne, and Arctic coast.
S. phlebophylla, Anders., Ounalashka, island of St. Lawrence, and Kotzebue sound.
S. polaris, Wahl., Wainwright inlet.
S. speciosa, Hook. et Arn., in Bot. Beechey, Kotzebue sound.
S. Richardsoni, Hook., Kotzebue sound to Cape Lisburne.
S. Barclayi, Anders., Kodiak.
S. phyllicoides, Anders., western Arctic America, (Avatscha bay, Seemann.)
S. cordata, Muhl., var. Mackenziana, Point Barrow, and along Arctic coast. This form Anderson regards as a hybrid between S. cordata and S. vagante.
S. Sitchensis, Ledeb., Sitka.
Populus balsamifera, L., Chilcaht, Kellogg; Youkon river, Dall.

URTICACEÆ.

Urtica dioica, L., Sitka, *fide* Bongard.

BETULACEÆ.

Betula glandulosa, Michx., Youkon river, Dall.
B. nana, L., Norton sound, Chamisso island, and Point Barrow.
B. Ermani, Cham., Ounalashka.
Alnus viridis, DC., Sitka, Ounalashka, Norton sound, Kotzebue sound, and northern coast, Youkon river, Dall.
A. rubra, Bong., Sitka.
A. incana, Willd., Kotzebue sound.

MYRICACEÆ.

Myrica Gale, L., Sitka.

CONIFERÆ.*

Abies Canadensis, Michx., Sitka.
A. Mertensiana, Bong., Sitka.

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† Mr. Dall collected, in the spring of 1867, a large number of willows, but owing to his short stay in a given locality was of course unable to match the sexes or to obtain the leaves. For want of material I am therefore compelled to pass them by.

* For want of material I am obliged to accept the determination of Ledebour's Flora Rossica in regard to this order almost "in toto." I have, however, kept up the distinction between *Abies* and *Pinus* for manifest reasons.

A. Sitchensis, Bong., Sitka.

A. alba, Michx., northwestern Alaska, where, according to Seemann, it grows from twenty to twenty-five feet high.

Pinus Cembra, L., Kotzebue sound, *fide* Bongard and Hooker and Arnott.

P. contorta, Dougl., Sitka. I can hardly think this is P. inops of Ait., as is alleged by some authors.

Thuja excelsa, Bong., Sitka and southern Russian America.

Juniperus nana, Willd., Sitka.

SALSOLACEÆ.

Teloxys aristata, Moquin-Tandon; Russian America, Pallas.

Atriplex littoralis, L., Kotzebue and Norton sound.

A. Gmelini, C. A. Meyer, Bong., Veg. Sitka, Kotzebue sound and Sitka.

Corispermum hyssopifolium, Stev., Point Barrow to Mackenzie river, Pullen.

Blitum capitatum, L., Fort Youkon, Rev. McDonald.

TYPHACEÆ.

Sparganium natans, L., Kotzebue sound and Ounalashka.

AROIDEÆ.

Lysichiton Kamtschatcense, Schott; Draconticum Kamtschatcense, L.; Symplocarpus Kamtschaticus, Bongard; Arctiodracon Kamtschaticum, Gray on the Botany of Japan, in Memoirs of American Academy of Arts and Sciences, new series, vol. 2, pp. 408–9; Sitka, Bischoff. I give the description and some remarks on the affinities of this plant, by Professor Gray, l. c.

Lysichiton Schott. "Spadix nudus, scapum terminans, cylindricus. Flores hermaphroditi, Perigynium tetraphyllum, basi ovarii adnatum, phyllis obovatis membranaceis subconcavis. Stamina, 4; filamenta plana; antheræ extrorsæ, biloculares, loculis ovalibus rima longitudinali ex apice fere ad basim dehiscentibus. Ovarium biloculare, rarius abortu uniloculare; stylus conicus, stigmate depresso simplici terminatus. Ovula in loculis solitaria, disseipmento paulo supra basim inserta, horizontalia, orthotropa. Pericarpia carnosa, 1–2 sperma, in recepataculum commune spongiosum coalescentia, stylo crasso-conico acuto apiculata, Semine haud visa.*—Herbæ paludosæ, boreali-Pacificæ, acaules; foliis magnis Symplocarpi cum scapo elongato coëtaneis e rhizomate crasso horizontali ortis; spatha vaginante superne in limbum lanceolatum seu ellipticum coloratum explanatum.

From our skunk cabbage the new genus is distinguished by the elongated scape, the membranaceous spatha or sheath, the spiciform spadix, the membranaceous perianth, the horizontal orthotropous ovules, and probably by the nature of the fruit, which I have not seen mature. I lay little stress upon the bilocular ovary, because one of the cells is occasionally abortive or wanting in the Japanese plant, and because the ovary of Symplocarpus itself not rarely exhibits vestiges of a second cell." Gray, l. c.

NAIDACEÆ.

Zostera marina, L., Ounalashka.

Potamogeton natans, L., Sitka.

P. rufescens, Besser, Ounalashka.

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* "Semen ventre planum, dorso convexum, ambitu ellipticum. Embryo macropodus."—Prodromus Systematis Aroideum, p. 420, H. G. Schott.

JUNCAGINACEÆ.

Triglochin maritimum, L., Sitka.
T. palustre, L., Ounalashka.

ORCHIDACEÆ.

Corallorhiza Mertensiana, Lindl., Sitka.
C. innata, R. Br., Kotzebue sound and Ounalashka.
Microstylis diphyllos, Lindl, Ounalashka.
Calypso borealis, Salisb., Sitka; Ferd. Bischoff.
Orchis latifolia, L., Ounalashka.
Platanthera obtusata, Lindl., Kotzebue sound.
P. Schischmareffiana, Lindl., Ounalashka.
P. Koenigii, Lindl., Ounalashka.
P. dilatata, Lindl., Sitka and Ounalashka.
Peristylus Chorisianus, Lindl., Ounalashka.
P. bracteatus, Lindl., Ounalashka.
Listera cordata, R. Br., Sitka and Ounalashka.
L. Eschscholtziana, Cham., Ounalashka.
Spiranthes Romanzoffiana, Cham., Ounalashka.
Cypripedium guttatum, Swartz, Ounalashka.

IRIDACEÆ.

Sisyrinchium Bermudiana, L., var. anceps., Sitka.
Iris Sibirica, L., Norton and Kotzebue sounds.

SMILACEÆ.

Streptopus amplexifolius, DC., Sitka and Ounalashka.
S. roseus, Michx., Sitka.
Smilacina bifolia, Ker., Sitka. The large-leaved form appears most common by far, if we may judge from the proportion of it in the collections made at Sitka.

LILIACEÆ.

Lloydia serotina, Reichenb., St. Lawrence and Ounalashka islands, Cape Lisburne and Kotzebue sound.

Fritillaria Kamtschatcensis, Fisch., Sitka, and Ounalashka, and Cape Prince of Wales.

Allium Schœnoprasum, L., Port Clarence, Norton and Kotzebue sounds, and rapids of Youkon river, Dall.

Zygadenus glaucus, Nutt., Kotzebue sound; Port Clarence, Arctic coast, and Fort Youkon, Dall.

Veratrum Eschscholtzii, Gray, Sitka.

Tofieldia coccinea, Richards., Kotzebue sound, Chamisso island, and Cape Lisburne.

T. glutinosa, Pursh, Sitka.

JUNCACEÆ.

Luzula pilosa, Willd., Sitka and Kotzebue sound.
L. spadicea, DC., Sitka, Ounalashka, and Kotzebue sound.
L. arcuata, Wahl., Kotzebue sound, islands of St. Lawrence and Ounalashka.
L. campestris,, DC., Ounalashka, Sitka, and Kotzebue sound.
L. spicata, DC., island of St. Lawrence and Kotzebue sound.

Juncus Balticus, Dethard, Cape Espenberg, Norton sound, and Ounalashka.
J. arcticus, Willd., Sitka.
J. ensifolius, Wickström, Ounalashka.
J. falcatus, E. Meyer, Ounalashka and Sitka.
J. castaneus, Smith, Sitka, Ounalashka, and Kotzebue sound.
J. biglumis, L., Kotzebue sound.
J. Drummondi, Ledeb., Ounalashka.
J. paradoxus, Meyer, is given by Ledebour as a doubtful native of Sitka.

CYPERACEÆ.

Scirpus cæspitosus, L., Ounalashka and Sitka.
S. sylvaticus, L., Sitka.
Eriophorum vaginatum, L., Sitka.
E. Scheuchzeri, Hoppe, Kotzebue sound, and Sitka, *fide* Mertens.
E. Chamissonis, C. A. Meyer, Sitka and Ounalashka.
E. callitrix, Cham., Island of St. Lawrence.
E. latifolium, L., including E. polystachyum, E. angustifolium, and E. gracile, Sitka, Norton sound to Point Barrow and the Arctic coast. "The silky hair of the cotton grasses is used by the Esquimaux as a substitute for tinder," Seemann.
Rhynchospora alba, Vahl., Sitka.
Elyna spicata, Schrad., Arctic coast, Pullen.
Carex leiocarpa, C. A. Meyer, Sitka and Ounalashka.
C. micropoda, C. A. Meyer, Ounalashka.
C. circinata, C. A. Meyer, Sitka and Ounalashka.
C. nigricans, C. A. Meyer, Sitka and Ounalashka.
C. pauciflora, Lightf., Sitka.
C. elongata, L., Sitka.
C. leporina, L., Ounalashka.
C. lagopina, Wahl., Kotzebue sound.
C. Norvegica, Willd., Sitka and Kotzebue sound
C. canescens, L., Sitka.
C. stellulata, Good., Sitka and Ounalashka.
C. remota, L., Sitka.
C. Buxbaumii, Wahl., Sitka.
C. Mertensii, Prescott, Ounalashka and Sitka.
C. atrata, L., Kotzebue sound.
C. Gmelini, Hook., Sitka, Ounalashka, and Kotzebue sound.
C. livida, Wahl., Sitka.
C. capillaris, L.; Ounalashka, Eschscholtz.
C. rariflora, Smith, Ounalashka; and Bay of Schischmareff, Eschscholtz.
C. rotundata, Wahl., Kotzebue sound.
C. macrochæta, C. A. Meyer, Ounalashka and Sitka.
C. melanocarpa, Cham., Island of St. Lawrence.
C. stylosa, C. A. Meyer, Sitka and Ounalashka.
C. limosa, L., Sitka.
C. saxatilis, Wahl., Kotzebue sound and Norton sound.
C. cæspitosa, L., Sitka and Kotzebue sound.
C. stricta, Good., Kotzebue sound.
C. aquatilis, Wahl., Ounalashka and Kotzebue sound.
C. cryptocarpa, C. A. Meyer, Sitka, Ounalashka, and Kotzebue sound.
C. acuta, L., Sitka.
C. vesicaria, L., Sitka and Kotzebue sound.
C. fuliginosa, Sternb., Kotzebue and Norton sound.*

* Not having access to Boott's great work on Carex I have followed Ledebour as the latest available authority. Most likely some modification of this list will yet be needed.

GRAMINEÆ.

Hordeum pratense, L., Sitka and Ounalashka.

H. jubatum, L.; Fort Youkon, Antoine Houle.

Elymus Sibiricus, L., Sitka.

E. arenarius, L., Norton sound to Point Barrow.

E. mollis, Trin., Sitka, Norton and Kotzebue sounds.

Triticum repens, L., Kotzebue sound.

Festuca ovina, L., Kotzebue sound.

F. rubra, L., Sitka and Kotzebue sound; united by Messrs. Hooker and Gray with F. ovina.

F. subulata, Bong., Sitka.

Bromus ciliatus, L., Kotzebue sound.

B. subulatus, Ledeb., Ounalashka.

B. Aleutensis, Trin., Ounalashka.

B. Sitchensis, Bong., Sitka.

Poa stenantha, Trin., Ounalashka, Sitka, and in America Arctica ad Fretum Senjawin, Ledebour Flora Rossica, vol. iv, p. 372.†

P. flavicans, Ledeb., Ounalashka.

P. arctica, R. Br., Kotzebue sound, Ounalashka, and Sitka.

P. cenisia, All., Ounalashka, Cape Lisburne, and Kotzebue sound. I here include P. abbreviata, Br.

P. rotundata, Trin., Ounalashka.

P. nemoralis, L., Kotzebue sound.

P. annua, L., Sitka.

P. pratensis, L., Kotzebue sound and Ounalashka.

Colpodium fulvum, Ledeb., Kotzebue sound.

Dupontia psilosantha, Rupr., Kotzebue sound.

Catabrosa aquatica, Beauv., Sitka; *fide* Ledebour

C. algida, Fries, Kotzebue sound.

Atropis maritima, Ledeb., Sitka.

A. angustata, Ledeb., Kotzebue sound.

Glyceria aquatica, Smith, Sitka.

G. glumaris, Ledeb., islands of St. Lawrence and Sitka, peninsula of Alaska, and Kotzebue sound.

Hierochloa borealis, R. and Schult., Ounalashka and Kotzebue sound.

H. alpina, R. and Schult., Ounalashka, Kotzebue sound, and Arctic coast.

Trisetum subspicatum, Trin., Ounalashka and Kotzebue sound; and from Point Barrow to Mackenzie river, Pullen.

T. sesquiflorum, Trin., Ounalashka.

T. cernuum, Trin., Sitka.

Aira cæspitosa, Trin., Ounalashka, and main land.

A. cæspitosa, Trin., var. Bottnica; Sitka, Bischoff and Kellogg. In looking over the specimens of A. cæspitosa in Herb., Gray, I find one from the Sandwich islands and another from Fort Vancouver, both of which appear identical with our forms from Sitka. They having been authentically named by Colonel Munro as Aira cæspitosa, var. Bottnica, I have labelled the Sitkan specimens in accordance with his determination. Trinius, in Icones Graminum, in the text fronting his A. flexuosa, var. Bottnica, speaks of an Aira very similar to A. Bottnica

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† Not being able to find fretum Senjawin in Arctic American maps, I applied to Prof. S. F. Baird for a solution of the difficulty. He informs me it is on the Asiatic side, latitude 64° 45′ north, longitude 172° 35′ west, between Kayne island and the Asiatic shore. Misled by Ledebour placing the strait on the American side, I concluded it must be the Seguam pass in the Aleutian island chain. However, as Professor Baird is positive, we may regard the locality as settled. Dr. J. D. Hooker seems to have experienced a similar difficulty in regard to the same locality.

being found at Sitka by Mertens. Bongard is silent on the subject in "Vegetation of Sitka," though I find in Herb., Gray, a specimen similar to the Sitkan ones marked (but from Ounalashka) as A. cæspitosa, var. longiflora. Trinius, l. c., vol. iii, writes of the same plant from Sitka, "cæterum hac varietate transitus quidam sistitur ab A. cæspitosa ad flexuosam;" which statement seems probable enough.

A. arctica, Trin., Kotzebue sound, Ounalashka, Sitka, and interior of the country.

A. atropurpurea, Scheele, Sitka, Ounalashka, and from Point Barrow to Mackenzie river.

Calamagrostis Aleutica, Trin., Ounalashka and Sitka.

C. purpurascens, R. Br., Fort Youkon. Rev. McDonald. Gray and Torrey regard this as a form of C. sylvatica, DC.

C. strigosa, Wahl., Sitka. Munro unites with this C. Aleutica, Bong.

C. neglecta, Gærtner, Kotzebue sound.

C. Lapponica, Trin., Ounalashka.

C. Canadensis, Beauv., Kotzebue sound.

C. Langsdorffii, Trin., Kotzebue sound, Eschscholtz.

Arctagrostis latifolia, Ledeb., Kotzebue sound and Arctic coast.

Cinna latifolia, Ledeb., Sitka.

Agrostis æquivalvis, Trin., Sitka and Ounalashka.

A. exarata, Trin., Ounalashka, Sitka, and Kodiak.

A. geminata, Trin., Ounalashka.

A. laxiflora, R. Br.; Ounalashka, Mertens.

Phleum pratense, L., Alaska, where it thrives well, according to Kellogg; but in what part of Alaska?

P. alpinum, L., Sitka and Ounalashka, Kotzebue sound, island of St. Lawrence, (and Arctic coast?)

Alopecurus alpinus, Sm., island of St. Lawrence, Kotzebue sound, (and Arctic coast?)

EQUISETACEÆ.

Equisetum arvense, L., Sitka and Ounalashka.

E. sylvaticum, L., Kotzebue sound.

LYCOPODIACEÆ.

Lycopodium Selago, L., Sitka, Ounalashka, and Kotzebue sound.

L. annotinum, L., Sitka, Ounalashka, and Kotzebue sound.

L. Sitchense, Ruprecht, Sitka.

L. complanatum, Sitka; *fide* Ledebour, Flora Rossica.

L. alpinum, L., Ounalashka.

L. dendroideum, Michx., Sitka; *fide* Ledebour, Flora Rossica.

L. clavatum, L., Sitka and Ounalashka.

Selaginella spinosa, Beauv., Ounalashka, Eschscholtz.

FILICES.

Ophioglossum vulgatum, L., Ounalashka, Eschscholtz.

Botrychium Lunaria, Swartz; Ounalashka, Chamisso.

B. rutaceum, Willd.; Ounalashka, Chamisso and Eschscholtz.

Polypodium vulgare, L., Sitka and Ounalashka.

P. Phegopteris, L.; Ounalashka, Mertens.

P. Dryopteris, L., Ounalashka and Kodiak.

Aspidium Lonchitis, Swartz; Ounalashka, Chamisso and Eschscholtz.

A. aculeatum, Swartz, Sitka.

A. spinulosum, Swartz, Sitka, Kotzebue sound, and Ounalashka.
A. fragrans, Swartz, Sitka, Kotzebue and Norton sounds.
Cystopteris fragilis, Bernh., Ounalashka and Kotzebue sound.
Asplenium Felix-fœmina, Bernh., Ounalashka, and Sitka. Kodiak?
Blechnum Spicant, Roth., Sitka; (Lomaria Spicant, Desv.)
Pteris aquilina, L., Sitka.
P. argentea, S. G. Gmelin, (America-Rossica, Steller ex Pallas.)
Allosorus Sitchensis, Ruprecht, Sitka. (Mihi ignota, Ledebour.)
A. foveolatus, Ruprecht, Ounalashka and Kodiak.
Adiantum pedatum, L., var., Ounalashka.

ANOPHYTES.

[DETERMINED AND COMPILED BY THOMAS P. JAMES.]

MUSCI.

Sphagnum cymbifolium, Ehrh.; Sitka, Bischoff.
S. teres, Wahl.; Nulato, W. H. Dall.
S. cuspidatum, var. recurvum, Beauv., Sitka.
S. acutifolium, Ehrh., Sitka and Alaska.
S. fimbriatum, Wilson; Kotzebue sound, B. Seemann.
S. fimbriatum, var. ramis denso compactis, foliis brevioribus subellipticis; Norton sound.
Weisia serrulata, Funk, Nulato.
Dicranum crispum, Hedw., Kotzebue sound.
D. polycarpum, Ehrh., Alaska.
D. heteromallum, Hedw., Alaska.
D. congestum, Brid., Sitka.
D. scoparium, Hedw., Kotzebue sound and Alaska.
D. elongatum, Schwæg., Kotzebue sound.
D. palustre, Brid., var. foliis planis nec undulatis, Sitka and Nulato.
D. majus, Smith, Sitka.
D. Schraderi, Schwæg., Kotzebue sound.
Barbula Mülleri, Br. and Sch.; Alaska, Kellogg.
Ceratodon purpureus, Brid., Kotzebue sound, Sitka, and Nulato.
Distichium capillaceum, Br. and Sch., Kotzebue sound and Nulato.
Tetraphis pellucida, Hedw., Sitka.
Ulota Barclayi, Mitten; Sitka, Barclay.
Racomitrium aciculare, Brid., Sitka.
R. fasciculare, Brid., Alaska.
R. canescens, var. ericoides, Brid., Sitka.
R. lanuginosum, Br. and Sch., Kotzebue sound.
Tayloria serrata, Br. and Sch., Sitka.
Tetraplodon mnioides, Hedw., Kotzebue sound and Sitka.
Splachnum sphæricum, Hedw., Norton sound.
S. vasculosum, Linn., Sitka.
T. urceolatus, Br. and Sch., Kotzebue sound.
Encalypta rhabdocarpa, Schwæg., Nulato.
Funaria hygrometrica, Hedw., Iktigalik.
Bartramia Menziesii, Hook., Western Russian America.
Conostomum boreale, Swartz, Kotzebue sound.
Bryum polymorphum, Br. and Sch., Sitka.
B. nutans, Schreb., Kotzebue sound, Sitka and Iktigalik.
B. crudum, Schreb., Iktigalik.
B. pyriforme, Hedw., Iktigalik.
B. lacustre, Brid., Kotzebue sound.

B. inclinatum, Br. and Sch., Kotzebue sound.
B. capillare, Hedw., Sitka.
B. argenteum, Linn., Iktigalik.
Mnium punctatum, Hedw., Sitka.
M. rostratum, Schwæg., Kotzebue sound.
M. affine, var. Zelatum, Br. and Sch., Sitka.
M. Menziesii, Hook., Sitka.
Aulacomnion turgidum, Schwæg., Kotzebue sound.
A. palustre, Schwæg., Kotzebue sound, Sitka and Nulato.
Pogonatum capillare, Michx. and Brid., Kotzebue sound and Sitka, Alaska.
P. alpinum, Linn., var. foliis capsulis longioribus, Kotzebue sound and Sitka.*
P. alpinum, var. furcatum, Brid., Schischimareff bay, (Chamisso.)
P. alpinum, var. campanulatum, Brid., Ounalashka, (Chamisso.)
P. atrovirens, Mitten, Sitka, (Barclay.)
P. contortum, Menz., northwestern coast of Russian America, (Menzies.)
P. dentatum, Menz., northwestern coast of Russian America.
Polytrichum gracile, Menz., Kotzebue sound.
P. formosum, Hedw., Alaska, (Kellogg.)
P. cavifolium, Wilson in Bot. Herald, (Seeman,) Kotzebue sound.
P. piliferum, Schreb., Alaska.
P. juniperinum, Willd., Kotzebue sound and Nulato.
P. juniperinum, var. strictum, Br. and Sch., Kotzebue sound and Sitka.
P. juniperinum, var. foliis distantibus, angustioribus patulis, Kotzebue sound, Sitka, and Nulato.
P. commune, Linn., Sitka.
Antitrichia curtipendula, Brid., Sitka.
A. Californica, Lesqx., Alaska.
Neckera Douglassii, Hook., Steekine, Alaska.
N. Menziesii, Hook., Alaska.
Alsia Californica, Lesqx., Alaska.
Hypnum triquetrum, Linn., Nulato and Alaska.
H. loreum, Linn., Sitka and Alaska.
H. squarrosum, Linn., Sitka.
H. crispifolium, Hook., Northwestern Russian America, (Menzies.)
H. laxifolium, Hook., Northwestern Russian America.
H. splendens, Hedw., Nulato and Alaska.
H. strigosum, Hoffm, Nulato.
H. undulatum, Linn., Sitka.
H. lutescens, Huds., Kotzebue sound and Alaska.
H. myosuroides, var. stoloniferum, Hook., Northwestern Russian America, Sitka, and Alaska.

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* Mr. W. H. Dall, in 1865–'66, collected a number of mosses in Eastern Siberia, on the western side of Behrings' straits, and opposite to Norton sound, among which was a new species of Pogonatum, which no doubt will be detected in Alaska, when explored. The species being interesting, it is deemed appropriate to introduce it by the following description:

Pogonatum lamellosum, sp. nov., dioicum, caule simplici vel ramoso, foliis solidis rigidis incurvis cauli appressis; e basi pellucida latiore amplexicaule, concavis lanceolato-acuminatis margine integra aut denticulata, lamellis numerosis margine subito tumidis, folii paginam e basi ad apicem totam occupante: perichætialibus e basi longioribus vaginantibus erectis angusto-lanceolatis, tenui costatis; perigonalibus externis angusto-lanceolatis, externis obcordato-apiculatis; capsula in pedicello flexuosa unciali, globosa vel ovato-cylindrica obliqua aut cernua, operculo e basi depresso-convexo rostellato incurvo conico, peristomii dentibus aqualibus; calyptra non visa.

This beautiful Pogonatum is more slender than *P. urnigerum*, the lamillæ of the leaves occupy the entire upper surface from the sheathing base to the apex; the leaves most readily separate from the translucent clasping base; the margins of the leaves are mostly entire, occasionally more or less denticulate at the apex. The capsule is globosely oval in form and curved, the operculum appears ~~to~~ be shortly rostrate.

H. Ruthenicum, Weinm., Sitka.
H. Schreberi, Willd., Sitka.
H. Stokesii, Turner, Alaska.
H. uncinatum, Hedw., Kotzebue sound.
H. uncinatum, var. majus, Wilson, twice as large as the ordinary form, Kotzebue sound and Alaska.
H. revolvens, Swartz, Kotzebue sound.
H. circinale, Hook., Kotzebue sound, Nulato, and Alaska.
H. rugosum, Hedw., Kotzebue sound.
H. illecebrum, Schwæg., var. caulis divisionibus subdendroidus foliis subintegerrimis, Alaska.
H. rivulare, Br. and Sch., var. foliis minus acutis, Kotzebue sound.
H. salebrosum? Hoffm., Kotzebue sound.
H. nitens, Schreb., Kotzebue sound.
H. denticulatum, Linn., Sitka.
H. serpens, Linn., Alaska.

HEPATICÆ.

Marchantia polymorpha, Linn., Alaska.
Fegatella conica Corda, Sitka and Iktigalik.
Fimbraria tenella, Nees? Alaska.
Jungermannia albicans, Linn., Alaska.
J. trichophylla, Linn., Alaska.
Scapania numerosa, Nees, Alaska.

LICHENES.

[LIST COMPILED BY H. MANN.]

Sphærophoron fragile, Pers.
S. coralloides, Pers.
Bæomyces icmadophilus, Nyl., Biatora icmadophylla, Auct.
Cladonia gracilis, Hoffm., Sitka and Kotzebue sound.
C. pyxidata, Ach., Kotzebue sound.
C. deformis, Hoffm., Kotzebue sound.
C. uncialis, Hoffm., Sitka and Kotzebue sound.
C. rangiferina, Hoffm., all Russian America.
C. sylvatica, Ach., all Russian America.
Pilophoron robustum, Nyl., islands of Behring's straits.
P. aciculare, Tuck., (Sect. of Stereocaulon,) Russian America.
Stereocaulon paschale, Laur., Kotzebue sound.
S. tomentosum? Fries, Kotzebue sound and other localities. Absence of fruit renders the determination doubtful.
Thamnolia vermiculare, common.
Alectoria ochroleuca, Fries, Kotzebue sound; on the ground the normal form: also, var. sarmentoso pendant from trees.
A. divergens, Nyl., various localities.
Cetraria Islandica, Ach., common.
Platysma cucullatum, Hoffm., common.
P. septentrionale, Nyl., Kotzebue sound.
P. glaucum, Nyl., Kotzebue sound.
Nephroma arcticum, Fries, Kotzebue sound.
Peltigera venosa, Hoffm., Kotzebue sound.
P. canina, Hoffm., Kotzebue sound.
P. polydactyla, Hoffm., Kotzebue sound, Sitka, &c.
P. apthosa, Hoffm., Kotzebue sound, Sitka, &c.

Sticta pulmonacea, Ach., Kotzebue sound, Sitka, &c.
S. scrobiculata, Ach., Kotzebue sound.
Parmelia perforata, Ach., Kotzebue sound.
P. perlata, Ach., Kotzebue sound.
P. saxatilis, Ach., Kotzebue sound.
P. tiliacea, Ach., Kotzebue sound.
Physcia parietina, D. N., Kotzebue sound.
P. stellaris, Fries.
P. obscura, Fries, Kotzebue sound.
Lecanora pallescens, var. Upsalensis, Fries, Kotzebue sound.
L. tartarica, var. frigida, Ach., Kotzebue sound.
Placodium elegans, Fries.
Psoroma hypnorum, DC.*

The list of *Fungi* and *Algæ* I have taken from Mr. Seemann's Report on the Botany of Western Esquimaux Land.

FUNGI.

Dothidea betulina, var. Betulæ nanæ, Fries, Kotzebue sound.
Erineum roseum, Schultz.

ALGÆ (*Auctore W. H. Harvey*)

Fucus vesiculosus, L., plentiful in Kotzebue sound.
Alaria esculenta, Grev., Arctic coast.
Chorda Filum, Stack.
Dictyosiphon fœniculaceus, Grev.
Chætopteris plumosa, Kutz.
Odonthalia dentata, var. angusta, Harv., Arctic coast.
Rhodomela Larix, Ag.
Delesseria sinuosa, Ag., Arctic ocean.
Phyllophora Brodiæi, J. Ag., Arctic coast, (single specimen of broad-leaved variety.)
Ahnfeldtia (Gymnogongrus) plicata, J. Ag., Arctic coast.
Nostoc verrucosum? Fresh water pools at Port Clarence.

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* All the lichens here enumerated, excepting the species Pilophoron, are of wide northern distribution, which the localities here indicated exhibit nothing of. Many other boreal species will reward search, and from some indications seen, we may expect the lichens of the southern part of Russian America to show some special affinities to the interesting lichen flora of California. H. M.

METEOROLOGY.

THE HURRICANE IN THE ISLAND OF ST. THOMAS, OCTOBER 29, 1867.

[*Translated from "The Diario de la Marina," Habana, January* 5, 1868.]

Public attention has been so much attracted to the hurricane which occasioned, October 29–30 last, such deplorable devastations in the islands of Porto Rico, St. Thomas, and other Antilles, that the following essay, embodying the reflections of an intelligent member of the Spanish marine on the law of these disturbances, and especially on the course pursued by the storm in question, will be read, we doubt not, with general interest:

"The late tempest, like other events of this kind, but to an extent rarely witnessed, has marked its path with incalculable disasters both on land and sea; especially the last, where the irresistible fury of the wind and waves seemed to threaten everything which they encountered with annihilation. God, however, in his infinite goodness, has given man intelligence, and placed in his hands the means of contending with difficulties and overcoming them; inspiring him with faith, the virtue which begets and sustains hope.

"The theory respecting *the law of storms* proves to us that however fearful these phenomena may be for navigators, they become much less formidable when science has once taught us the nature of our elemental foe, and consequently the means of avoiding its destructive violence, in as far at least as is humanly possible. Towards the end of the 16th century, a knowledge already existed of the circular form of these tornadoes; but, as happens with many things of importance which sleep in oblivion and again reappear as novelties, the knowledge of the above fact bore no fruits, until Mr. W. C. Redfield, of New York, from 1831 to 1835, brought to light, by force of investigation, the definite law of the movement of rotation of hurricanes, as well as that of their translation, with other circumstances attending them, conformable in all points to the observations of other authors of accredited reputation.

"The storm of the 29th of October, which inundated Tortola, devastated St. Thomas, ravaged many parts of Porto Rico, and made itself felt in the capital of St. Domingo and the adjacent villages, affords one datum more to be collated with others for continuing the study of the movement of hurricanes. It results from the notices we have been able to collect, though these are not so precise as to enable us to judge with entire certainty, that the hurricane in question took its rise in 50° to 55° west longitude, and 18° to 20° north latitude, a space comprised in the region of their usual origin. The mail steamer *Principe Alfonso* encountered it in her course two days before reaching this port, and her skilful commander avoided it by suitably tacking ship until he thought that he might pursue his voyage without risk, thus arriving safely in the rear of the hurricane without experiencing any great inconvenience. Sr. Lastra assured me that he had steered in conformity with the prescribed rules as soon as he suspected that he was in the neighborhood of a tornado.

"Knowing very nearly the point of its formation, it will be seen that the course of the tornado was about W. ¼ SW. until having passed St. Thomas it took a direction W. 5° N., advancing at the rate of 13 to 15 miles an hour, the vortex or *focus* passing by the centre of the island of Porto Rico, as would appear from the fact of Naguabo, Humacao, and Caguas, with certain other places, having been most severely visited. The calm which was experienced in Cayey, at the veering of the wind, is a convincing proof that the centre of the storm passed at that point, for it is a characteristic circumstance of such

meteors that they rotate around an area of calm of variable extension. The central calm in question might be from three to four miles in diameter, judging from the interval between the subsidence of the wind from the north and the commencing violence of that from the west; of which precise moment the gallant and sagacious commander of the steamship *Vasco Nuñez de Balboa* knew how to avail himself in order to pass from the shore to that vessel, at the risk of perishing if this centre of calm had been of two minutes less duration. The diameter of the hurricane I take to have been from 40 to 50 miles, and that of its greatest force some 20, since in this port and that of Arroyo it was felt with less intensity than at other points more inland and distant from those places 15 to 20 miles. That the disturbance is of a circular form, or of a curvature approaching that figure, is once more shown by the circumstance of the wind's blowing at the same time in two distinct points, which may be considered as diametrically opposed in regard to the centre or *focus* of opposite rhombs; for example, at the same hour when, at Porto Rico, the direction was from NE. to E.NE., at Arroyo it was from W. to SW., at Salinas from W. to S., and at Naguabo to the S.

"We have at present no notices of the passage of the hurricane beyond the western part of St. Domingo, which leads us to think that it terminated in that island or pursued a course more to the north, leaving the south of Cuba fortunately unvisited, and arriving at the coasts of Florida; a route which these storms generally follow as far as the eastern part of the New World, where they subside.

"Barometers fell, at St. Thomas to 28.20; in this port (at the Captainship) to 29.60; on board the schooner *Andaluza* to 29.60; at Arroyo to 29.40. We have not been able to verify the state of the atmosphere at other points of this island; the instruments, it would seem, not having acted with the promptness usually observed, and the descent having only commenced when the tempest was near at hand; which may have happened from their having been, for some days, lower than ordinary under normal circumstances, and from the influence of the north winds which had been prevailing before the hurricane, so that the latter exerted not a mediate, but an immediate influence. As regards extension, I consider this hurricane to have been one of the narrowest kind, as in general such disturbances have a larger diameter by some miles and embrace a proportionably wider zone.

OBSERVATIONS REGARDING THE EARTHQUAKES WHICH OCCURRED IN ST. THOMAS AND NEIGHBORING ISLANDS, COMMENCING NOV. 18, 1867.

By George A. Latimer.

The earthquakes which began on 18th November, 1867, and have since been frequent, seem to have had their origin by the bursting out of a submarine volcano in the sea somewhere about or between the Danish islands of St. Thomas and St. Croix. The reasons for this opinion are:

1. The great wave which soon followed the first heavy shocks was seen for some time rolling on towards St. Thomas and Porto Rico, from the south to the north, while at the same moment another similar wave (perhaps even larger than the first) rolled on towards St. Croix, from the north to the south; thus showing that the volcanic eruption which caused them had occurred in the sea somewhere between those two islands, and that the force sent the water in both directions.

2. It is historical that some 75 years ago the small island of Saba, (Little Saba, as it is called,) just west of the harbor of St. Thomas, was an active volcano, and on the 18th and 19th November last emitted smoke; thus showing the volcanic action was not distant.

3. Previous to November 18, 1867, earthquakes had not been felt in St. Croix; on that day they were, and subsequently they have been simultaneously with the shocks felt in St. Thomas; showing thereby that a communication had and has been opened between the two islands. The shocks extended to Porto Rico, and were felt throughout most of it; but the force of, and damage done by them to buildings, sugar estate works, and chimneys, was chiefly at the east end, the north side as far down as Arecibo, and the south side as far down as Ponce. Below those places, neither on the north nor the south side was any damage done to the buildings. The greater rolling wave passed into the harbor and over the beaches at the east end, and down the south side of the island, (Porto Rico,) but it did not extend to the north side or west end.

AN OPINION ON THE MARITIME DISASTERS OF THE ANTILLES.

Under the above title, D. Aristides Rojas has published, in the *Federalista* of Caracas, the interesting remarks which ensue, chiefly for the service of those among us who are occupied with analogous studies:

"Having had inquiries addressed to me respecting the catastrophe which is reported to have taken place in the island of St. Thomas, 18th of the present month, I hastily reduced to writing the following propositions, which have since appeared in the *Federalista* of Thursday, November 28.

"1. A series of concussions of the earth during four consecutive days may have produced displacements at profound depths, and to this would be attributable the inundation of the lower part of the island and the irruption of the ocean; in this case the phenomenon was merely local and the hurricane of the 13th must have contributed in great part to produce it.

"2. It may have had its origin in remote regions; and, in that case, as well the concussions of the earth as the irruptions of the ocean would have extended over the adjacent coasts of Porto Rico and St. Domingo to the west, and the Virgin islands and lesser Antilles to the east, occasioning ravages in all those places. Supposing the concussions of the earth and the subterranean noises to have been continuous, (as the captain of the Cacique represents was the case in San Pedro de Martinica,) should the phenomenon be attributed to local causes, or to seismic causes operating at a distance? Were the series of concussions which have been felt of late in the regions of Ecuador, New Granada, and Venezuela connected with the catastrophe of St. Thomas?

"Founding my opinion on the movements which have occurred in various sections of the continent, I have come to the conclusion that the event in St. Thomas was not local, but, on the contrary, that it bore a relation to general causes which had been in operation beforehand and under vast surfaces of the American continent. The notices just received tend to confirm this view of the phenomenon. As our readers know, it was on the 18th that the series of earthquakes which desolated St. Thomas began, and that they continued till the 22d. The same day concussions occurred in Guadaloupe and repeated shocks commenced in Porto Rico, continuing until the 24th, and driving the population of the capital, in affright, from their tottering houses and fortresses. On the 18th, also, the ocean invaded the capital of St. Thomas, devastating all the lower part, while in Guadaloupe and Martinique, to the east, the water retired 15 metres in the former island and little less in the second. On the 19th the island of Margarita, east of Caracas, was repeatedly shaken, vast waves dashed upon the coast, attaining in some places six fathoms in height. Caupano, on the main land, had a portion of its pier demolished.

"So far the notices received; but from these it may be inferred, I think, without the least risk of error, that concussions must have been experienced in

the regions lying east of Venezuela, attended by the same marine phenomena. As regards the Antilles, I doubt not that the convulsion which ravaged St. Thomas must have visited Porto Rico, St. Domingo, and some of the lesser Antilles. If the oscillations in Porto Rico were, as I presume, east and west, they will have held on in the direction of the Cordilleras of the Antilles, and, in that case, the concussions, instead of being limited to St. Thomas and Porto Rico, will have extended to the whole archipelago.

"How, now, is this phenomenon to be explained? I stand in need of data and details on the direction of the movements, as well at St. Thomas and Porto Rico as at the remaining islands; but, confiding in the above data and a study of this branch of geology, I venture to assume that, beneath the American continent, there had been formed a scismic tempest, (when I say tempest, I mean a series of movements within the crust of the earth,) which, after manifesting itself by repeated shocks in Ecuador, New Granada, and Venezuela, was discharged over the whole Antillan continent. Let us recapitulate the facts, taking as a point of departure the strong concussion of Guayaquil:

"September 11. Earthquake in Guayaquil and volcanic detonations on the preceding days.

"15. Strong concussions in the Venezuelan Andes (Canache and other places) at 2 p. m.

"20. Repeated commotions in the central Cordillera of New Granada, on this day as well as those which preceded and followed it.

"22. Slight concussion at Caracas, about 12 at night. Direction SW.

"28. Strong shocks in the Venezuelan Andes between 7 and 8 at night.

"October 10. Strong concussions in the Venezuelan Andes at 5 a. m. A slight shock at Caracas at 2 p. m. the same day, attended with reports.

"24. Strong concussion at Petare (little felt at Caracas) at 6 minutes before 2 p. m.

"26. Slight concussion at Caracas at 10 p. m.

"November 2. Idem at Caracas at 5 minutes to 4 a. m., and again on the 10th at 10.50 p. m. and another some minutes afterwards. Again on the 15th at 4.50 p. m.

"The southeast direction of the slight concussions which were felt in Caracas a few months ago show that the movement came from the Andes, and in support of this opinion I would remind my readers of the strong shocks which were felt in April in the city of Mérida, and which continued uniformly to the west, attaining Maracaibo, while to the north they reached Caracas intermittently, together with the neighboring towns.

"The direction which this scismic tempest has pursued and still pursues is indicated by an orbit which, starting from the Chilian and Peruvian Andes, proceeds to Ecuador, passes to the east of the Andes of Granada, traverses Venezuela by the bay of Barcelona, and advances to the east of Porto Rico, between that island and St. Thomas. The tempest is discharging itself, at the present moment, on the great and lesser Antilles, and its shock in that region is in turn acting upon the eastern part of Venezuela, producing the earthquakes of Margarita and Carupano and the elevation of their seas."

ACCOUNT OF AN ERUPTION OF A VOLCANO IN NICARAGUA, NOV. 14, 1867.

By A. B. Dickinson, United States Minister, Nicaragua.

On the 14th of November last, a new volcano broke out in Nicaragua, about eight leagues to the east of the city of Leon, on a crowded line of volcanoes running through the State, parallel with the Pacific coast.

It commenced about 1 o'clock in the morning, with a succession of explosions

which were very distinctly felt and heard at Leon. These explosions opened a fissure through the earth's crust, about half a mile in length, running from the old fissure in a southwest direction, about midway between the extinct volcanoes of Las Pilas and Orota, which are two of the numerous cones studding the ancient fissure.

Before daylight on the morning of the 14th, fire was seen issuing from the new volcano in various places. The explosions continued irregularly during the whole time that the volcano was in a state of eruption, sometimes in rapid succession and at other times at intervals of half an hour. Low, rumbling sounds were heard almost incessantly. In the course of a few days two craters were opened on the new fissure, about 1,000 feet apart, the one at the south-western extremity discharging perpendicularly, and the other shooting out towards the northeast at an angle of 45 degrees. The flames from these two craters steadily increased in height and size, while jets of flame and slighter discharges were emitted from two or three other side fissures.

On the morning of November 22d, I went out to the new volcano for the purpose of observing it more closely, though I had seen and heard it very plainly each day and night from Leon. The best view which I obtained of it on that occasion was before daylight, from a mountain summit, about one mile to the north-west of the fissure and at right angles with it. The main crater, at the right, was actively at work, throwing out flames and half-melted cinders through a circular orifice about 60 feet in diameter, which was constantly filled to its utmost capacity with the ascending masses. A regular cone, built up entirely by the falling cinders to the height of about 200 feet, had already formed around the crater. The rim of the cone was white with heat and the outside red hot half way down, while the remainder of its black groundwork was glittering with innumerable glowing sparks. It was puffing quite regularly about once a second, with a strong, constant blast, which kept up a column of flame, filled with flying cinders, to the height of about 500 feet above the mouth of the orifice. Irregular explosions occurred at intervals, varying from 10 to 30 minutes, increasing the force and volume of the discharges, and sending them far up into the rolling clouds above. The cinders went up in half-fused, blazing masses, from one to three feet in diameter, and came down upon the cone hardened, striking with a clinking, metallic sound. After daylight the red appearance of the cone changed to a bluish black. The left hand crater was shooting out oblique discharges of flame and cinders of a similar character, at an angle of 45 degrees from the other, and evidently communicated with it about 1,000 feet below the surface—the two craters being that distance apart, and both discharging simultaneously. This half-horizontal crater was about 20 feet in diameter.

The afternoon of the 27th, after a series of explosions which seemed to shake the earth to its centre, the volcano commenced discharging vast quantities of black sand and heavier rocks. The column of flame at night was considerably increased in height, and bright, meteor-like spots were seen ascending in the flames to the height of not less than 3,000 feet. These were large, spherical stones, four and five feet in diameter. The next morning the house-tops and streets of Leon were covered with fine black sand from the volcano, and a vast luminous cloud of raining sand overspread the whole surrounding country. This rain of sand continued until the morning of the 30th, when the volcano died away, apparently smothered by its accumulated eruptions. The sand now covers the whole surrounding country, from the volcano to the Pacific, a distance of more than 50 miles from it. At Leon it is from an eighth to a quarter of an nch in depth. As we approach the volcano it gradually grows deeper and coarser. For a mile around the crater it lies in particles from three-eighths to one-half an inch in diameter, and about a foot in depth, and the particles gradually increase in size until they become small, broken rocks.

Around the base of the cone, round, heavy rocks lie thickly scattered, from four to five feet in diameter, but much the larger portion of them have broken into fragments. The cone itself is 200 feet high, with a crater in the top of 200 feet in diameter and about the same in depth. The inside of the crater, the same as the outside, is covered with hard, broken rocks, generally less than a foot in diameter. A long ridge of black scoria leads out from the branch crater in a northeasterly direction. The slaggy, lava-like scoria which first issued from the main crater is now principally covered up with the hard plutonic rocks which came out from profound depths with the last discharges. The forest, for leagues around, is scarred and maimed with the sharp cutting storms of sand, and near the volcano the trees lie, cut into numerous fragments, half buried beneath the sand and rocks.

The volcano was an active and interesting sight for 16 days, and now in its repose affords an ample and instructive field for the geologist. Indeed, no country in the world presents a more interesting study than the plain of Leon. Twenty volcanic cones are seen rising from it at a single view. Its soil is inexhaustible in fertility, as finely pulverized and as evenly distributed as that of the valley of the Nile or the Mississippi, not however by water, but by fire. It has literally rained down from the volcanoes, richly freighted with fertilizing materials.

Humboldt regretted, before his death, that men of science had not more fully investigated this remarkable region of country, and it is sincerely to be hoped that it may not much longer remain neglected by them.

The recent fall of sand has been followed by a shower of rain, and though but a few days have since elapsed, corn, cotton, and grass have grown more rapidly under its fertilizing influence than I have ever seen plants grow before. Some weeds and plants it kills; others it starts forth with renewed life and vigor.

I send herewith a specimen of the sand, gathered at Leon before the rain, hoping that it may be analyzed.

It may be proper in this connection to call attention to the recent destructive storms, earthquakes and eruptions which occurred on and around the island of St. Thomas during the same period of time which I have been describing, and which undoubtedly sprang from the same general cause, as those earthquakes were distinctly felt at Leon.

SECOND COMMUNICATION.

I have the pleasure to acknowledge the receipt of a letter from the Smithsonian Institution, containing a number of questions in regard to the recent volcano in Nicaragua, which I will endeavor to answer as accurately as possible.

The latitude of the volcano is 12° 30′ north, the longitude 86° 45′ west from Greenwich, according to the government map of Nicaragua. Its distance from the Pacific ocean is 40 miles.

The strong east wind prevailing here at this season of the year, and particularly during the late volcanic eruption, brought the sand mostly to the westward, but as fine sand was also carried in lesser quantities many leagues to the eastward, it probably also partially entered the upper and counter current of air. It is known to have extended 100 miles to the westward, covering a belt about 100 miles in width. At the commencement of the rain of sand the wind carried it in a northwest direction; but for the last 24 hours of the sand storm the wind carried it to the southwest.

Over an area of about 100 miles in diameter the sand averages at least one-eighth of an inch in thickness.

The rainy season usually commences here about the middle of May and ends the middle of November; the remainder of the year being the dry season. The rainy season is without wind, but during the dry season high winds sweep over

the country to the westward. This wind usually commences about the 1st of December, but this last year it commenced about two weeks earlier, which was about the time the volcano broke out. The rainy season closed also the 1st of November last. The usual appearance of the sun and sky in November is remarkably bright, spotted over with white, fleecy clouds. But during the latter part of the volcanic eruption, and for two weeks after its close, the atmosphere was greatly disturbed, and for several days in succession scarcely a patch of clear sky was visible; dark gray clouds were constantly whirling in heavy masses to the westward, alarming the inhabitants with their sombre and threatening appearance. The explosions and the crackling roar of the volcano were heard for a distance of over 100 miles, to the west, northwest and southwest.

On the evening of November 22, while the volcano was in an active state, I started from Leon a little after midnight, to make a visit to the volcano before daylight, and on that occasion, at 2 o'clock in the morning, about 10 miles to the west of the volcano, I encountered, very much to my surprise, a heavy shower of rain, accompanied by thunder and lightning. The thunder, however, was not easily distinguished from the roar of the volcano.

My attention was then particularly called to the fact that the storm came out of the dense black cloud which ascended in a vast column from the crater, and overhung the surrounding country for several leagues in extent. It was bright starlight when I started from Leon, and no other cloud was visible. I could also still see the clear, star-lit horizon on every side of me, except that of the black cloud from the crater. During this evidently volcanic shower I was first struck with the peculiar, offensive odor of the volcano, which I afterwards became familiar with. After approaching nearer to the volcano, and far enough to the eastward to see through the cloud, I saw that the horizon was also cloudless in that direction. I passed the limits of the shower to the north and west, and also to the east. The shower was confined entirely to the west side of the volcano, extending fifteen miles to the westward, and covering a belt about 10 miles in width, which showed from standing water and muddy ground that this was by no means the first shower.

I have since ascertained from natives of the country that during the eruption showers in that vicinity were almost daily, and that on one occasion it rained hot water. But a single shower, however, reached as far as Leon. Brilliant flashes of red and white were constantly darting from the crater into the cloud above, and the lightning struck out in every direction from the jet of eruption where it came in contact with the cloud.

With regard to the earthquakes I am unable to answer your questions satisfactorily. It was distinctly felt here, and several others have also occurred since that time, but they have all been so slight and little noticed that the direction or extent of the earth-wave has not been observed. It is reported to me, also, that shocks of earthquake have been quite frequent of late in San Salvador.

Permit me to thank you for your account of the examination of the volcanic sand which I had the pleasure to receive by last mail.

[The following is an account of the examination of the specimens by Professor George J. Brush, of Yale College.—J. H.]

The volcanic sand appears to consist mainly, if not entirely, of three minerals: 1st. An olive-green mineral, in angular fragments, which is evidently *chrysolite*, (olivine). 2d. A colorless, transparent mineral, also in angular fragments, is probably a *feldspar*, but what particular species I am unable to say. 3d. A grayish black to black substance, in many cases with the edges rounded from semi-fusion; appears to be an *iron angite*, (or hornblende.) It is magnetic, as is the case with the fused iron angites. These minerals are constantly found in the ejections from volcanoes and are constants of many lavas.

CLOUD-BURSTS.

COMMUNICATED BY WILLIAM J. YOUNG, OF BOISE CITY, IDAHO TERRITORY.

You are probably aware that in the Great Basin, between the Rocky and Sierra Nevada range of mountains, but little rain falls during the summer months. I wish to call attention to a singular phenomenon that is observed in that region during the dry season.

An old mountaineer and prospecter told me that one night in the summer of 1862, he, with several others, camped in a cañon near Black Rock. Some time during the night he was awakened by a roaring as of a storm in the mountains; yet the night was clear—no cloud was in sight. But soon the water came rushing in torrents down the cañon, and drove the party to higher ground. He said such floods were not uncommon in that region, and were occasioned by water-spouts.

J. H. Neale, esq., a very intelligent merchant, who has spent the last two years in that region, says:

"In August, 1864, I was travelling from Humboldt mines to Reese river. The whole country was dry and parched, as is usual at that season of the year, and the weather was even warmer than common. About 2 o'clock p. m. I saw what appeared to be a whirlwind. It appeared to be about 25 miles distant, and the spiral column extended from the earth to a very dense cloud, which was nearly as high as the scattered mountains in that vicinity. Soon this column seemed to break, the upper third of it being detached from the rest and bent over to the eastward. I then perceived that this spiral column was not of dust, as I had at first supposed, but was water. The next day I crossed a cañon leading from the place where the phenomenon had occurred. Water was still running in it, and there was evidence of a recent flood."

Inquiring further, I consulted the Hon. William R. Harrison, a gentleman of scientific attainments who had spent several years in the Humboldt mountains. He told me that such phenomena were of not unfrequent occurrence in the Humboldt mountains, and were called "cloud-bursts." He had witnessed several of them—had once been in the edge of one, and once had stood on the top of a mountain and witnessed the terrific scene in the cañon beneath him. He says:

"The first sign of them is the sudden gathering of a small, dense, black cloud on the mountain side, about one-third of the way from the top, and generally at the head of a cañon. Soon this cloud seems to dash itself to the earth, taking a circular motion. It appeared as if an inverted whirlwind was drawing from the cloud immense quantities of water, which is dashed in floods against the mountain side."

By these floods, he said, he had known trees uprooted, and rocks, tons in weight, carried by the torrent the eighth of a mile. On one occasion the water in the cañon leading from the "cloud-burst" was 30 feet deep. The area that receives this immense body of water from the cloud is not generally more than one hundred yards in diameter, and sometimes is much less. Star City (Humboldt mines) was once damaged by such a flood. I have heard (on this my information is not direct) that in 1862 several persons lost their lives by one of these "cloud-bursts," somewhere in the Washoe region. These storms are entirely different from anything I ever heard of occurring in any other part of the world. They occur where the sky is elsewhere clear and cloudless. From the first gathering of the cloud until the storm has passed and the sky is again cloudless is seldom more than an hour, and does not generally exceed forty minutes.

The cause of these phenomena may be familiar to scientific men, but to the uninitiated it is a mystery how such quantities of water can be so suddenly collected from the burning air of these desert plains.

Professor Espy collected a number of cases in Pennsylvania and other parts of the eastern States, of examples of this remarkable phenomenon. The only explanation which appears to be sufficient to account for it, and particularly the amount of water which falls, is that of a water-spout or rotatory motion of the air, produced by the disturbance of the ordinary stable condition of the atmosphere by the abnormal heating of the stratum next the earth, and the subsequent bursting of this upward, in the form of an ascending vortex, carrying with it all the vapor which the air may contain from a surrounding space of several miles.

The quantity of water which falls will depend upon the amount of vapor in the atmosphere which has been drawn into the vortex. It should be recollected that although the air may be very dry at a high temperature, yet it may contain a much greater quantity of water in the form of vapor than a damper atmosphere at a lower temperature. Thus, at 70° of temperature the air, when perfectly saturated, contains about eight grains of vapor to the cubic foot; at 90° it is capable of containing about 15 grains. From this it appears that the capacity for vapor increases very rapidly with the temperature; in the case above cited an increase of 20° of temperature nearly doubles the capacity for moisture, and consequently produces a character of extreme dryness.

Although, at the same time, the air may contain a very large amount of vapor which, condensed by a diminution of temperature due to its increased elevation, or perhaps by a colder stratum immediately above, may be precipitated on a single spot, and thus give rise to the extraordinary effects above described.

ACCOUNT OF A METEORITE.

By Abner Woodworth, Council Grove, Kansas, March, 1866.

On the 7th of March, 1843, I left Paral, a town situated on the river Allende Mexico, State of Chihuahua, and, travelling some 25 miles, course 15° east of south, passed a lump of solid malleable iron, shape or figure resembling two inverted saucers, one-third or more buried in the ground, supposed to weigh five or six thousand pounds. It is softer than bar iron. The blacksmith at Rio Florido cuts off pieces with his cold chisel for horseshoes. It lies upon a level plain, 20 miles from any mountain.

ACCOUNT OF A METEORITE.

By Robert Simson.

Shortly before arriving at El Valle, on the road from Rio Florido, we encounter first streaks of iron—grateful to the lips and hands, cracked and sore with the lime through which we have for some time been travelling, (going northward.) The hill-sides, where bare, now show a reddish color; and vegetation is not so luxuriant as heretofore.

About half-way between El Valle and Parral, on a bend of the Rio Florido, at a place called Concepcion, is a most splendid specimen of meteoric iron. It is four feet above ground, and almost pure in quality. It is from two to three feet one way, by, probably, two to five feet the other, very regular in shape, and, where worn by the rubbing of hands, &c., of passers by, is bright, and, to all appearance, is nearly pure metal. The steel hatchet cuts into it easily, but with our means at hand we found it impossible to detach any part of it. It stood at the corner of the house, apparently to guard it from collisions of wagons

and the like. The majordomo said this meteorite had, as he had heard, fallen from the heavens, and had been brought from a distance, from a place where other specimens also existed. Such we found to be the prevailing account of this mass among the people of the place.

I would state that from La Concepcion to the Rio Grande there is an excellent road leading through Saltillo and Monterey, and, save in respect to its weight, there would be no difficulty in conveying this meteorite. I think, also, that, being cautiously approached, the Mexicans would sell it for a reasonable sum. The common carts of the country, with solid wooden wheels, could well convey it.

I extract the foregoing partly from my own memoranda and partly from memoranda of John W. Audubon, esquire, now deceased, who examined the specimen with me.

At Parral are large works for reducing the silver ores, which are in great quantity in its neighborhood.

[It would appear, from all the acconnts we have had from this region, that a shower of immense meteorites had occurred there at some remote period.—J. H.]

THE METEOROLOGY OF CARACAS, VENEZUELA, SOUTH AMERICA.

By G. A. Ernst.

The town of Caracas is situated in a small valley of the northern coast chain of Venezuela, in latitude 10° 30′ 50″ north, and in longitude 66° 54′ 51″ west of Greenwich.

Its altitude above the level of the Caribbean sea, at Laguayra, was determined August 23, 1866, from the following observations:

At lower station, (wharf at Laguayra,) barometer 760^{mm}, attached thermometer 26°.0 C., thermometer in open air 26°.7 C.; latitude of Laguayra 10° 36′ 15″ north; at upper station, (Plaza Bolivar,) barometer 686.2^{mm}, attached thermometer 21°.7 C., thermometer in open air 21°.7 C. Converting the above data into English measure, we have

Inch.	°	°
β =29.031*	t =80.06 F.	τ =78.8 F.
β^1=27.025	t^1=71.06	τ^1=71.06

and by means of Baily's tables, (see Manual of Scientific Enquiry, London, 1859, p. 168,) we find the difference of elevation 2923.5 English feet.

As far as I know there is no one at present engaged in this place in meteorological observations. Dr. Alexander Ibarra kept a journal for several years, but it is now discontinued. With proper instruments, it would give me pleasure to register the meteorological facts. My instruments were unfortunately broken in an ascent to the Silla de Caracas, and I have not yet been able to replace them with new and better ones.

I copy from the "Annuario de Observaciones de la Officina Central del Colegio de Ingenieros de Venezuela para el año de 1862," the following meteorological table for 1860, constructed from the observations of Dr. Ibarra. The original record of the temperature is given in degrees of the Centigrade scale, and of the atmospheric pressure in units of the French scale; both were reduced to English units, which are commonly used in the United States. For the reduction of the barometric observations I would again refer to Appendix A.

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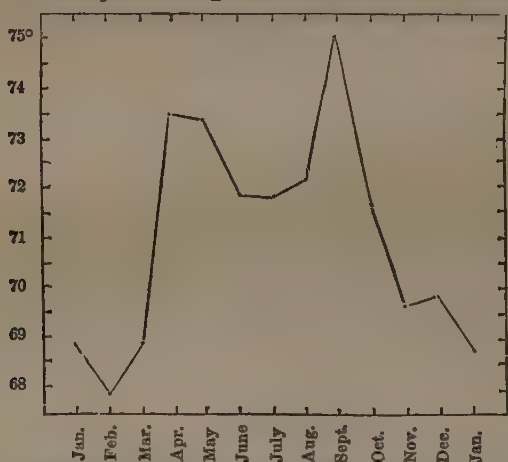
* See Appendix A.

Month.	Mean temperature.	Mean atmos. pres.	Humidity, Saussure's hyg.	Amount of rain.*
	°	*Inches.*	°	*Inches.*
January	69.28	26.960	71.64	0.158
February	68.36	26.971	66.00	0.000
March	69.44	26.954	72.70	0.670
April	75.01	26.964	73.10	3.349
May	73.88	26.984	68.00	0.473
June	72.41	26.975	68.65	3.664
July	72.32	26.980	72.80	4.452
August	72.62	26.964	75.90	4.373
September	75.50	26.956	76.40	8.116
October	72.10	26.946	76.90	5.595
November	70.19	26.938	76.50	3.791
December	70.37	26.959	73.85	0.083

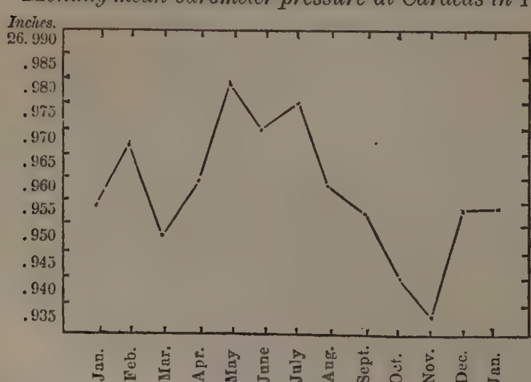
* In French inches.

The correct mean annual temperature† is therefore 71°.71, and the mean annual barometric pressure $26^{in}.963$; the average degree of humidity 72°.70, and the total amount of rain in 1860, 34.724 inches. The following diagrams show the annual march of the temperature and barometric pressure, as observed in 1860:

Monthly mean temperature at Caracas in 1860.



Monthly mean barometer pressure at Caracas in 1860.



† See Appendix B.

Determination of the height of the Silla de Caracas, at noon March 26, 1867.

At lower station (wharf at Laguayra):
Barometer $759^{mm}.32$, or 29.904 English inches.
Attached thermometer 24°.2 C., or 75°.56 Fah.
Thermometer in open air 24°.2 C., or 75°.56 Fah.
At upper station, (top of the Silla de Caracas,) in latitude 10° 31′ 15″ north:
Barometer $557^{mm}.5$, or 21.956 English inches.
Attached barometer 13°.8 C., or 54°.84 Fah.
Thermometer in open air 13°.8 C., or 54°.84 Fah.
Hence by Baily's tables, elevation of the Silla de Caracas 8,658 English feet, or 5734.5 feet above Caracas.

APPENDIX A.

[From the *Reader*, Dec. 10, 1864, p. 740.]

It appears to be the ordinary practice of instrument makers, when constructing a barometer with the English and French scales, to turn to the tables for the conversion of inches into millimetres, or *vice versa*, and to assume that the equivalents there found are to be implicitly adopted. I am far from blaming them for this assumption, but merely wish to show that it should in future cease to be acted upon. An examination into the data on which these tables are constructed shows that they merely profess to give the equivalent of English inches *at the standard temperature of the yard* (62° F.) in millimetres *at the standard temperature of the metre* (0° C., or 32° F.) Hence the reading of the metrical scale of a barometer corresponding to any given number of inches should be the tabular equivalent less a correction for the expansion of the scale between the respective standard temperatures (0° C., 62° F.,) or for a range of 30° F. (16°.67 C.) It will be at once apparent that, at the same pressure, the amount of this correction will be constant, whatever be the temperature *common to the two scales*.

An example will render my meaning clearer. Let the barometric reading on the English scale be 31 inches, the equivalent of which in the tables is 787.37 millimetres, based on the assumption that the temperatures of the scales are respectively 62° and 32° F. If the attached thermometer indicates 62° it is clear that the requisite condition is not realized in the case of the metric scale, which must therefore be corrected. Let A be the linear expansion of brass for 1° C. = 0.000018782; B the metrical reading = 787.39^{mm}, and t the temperature = 62° F., or 76°.67 C.; then

A B t = 0.000018782 times 787.39 times 16.67 = 0.247^{mm}, the amount to be deducted from the reading of the metrical scale equivalent to 31 inches, as given in the table, in order to reduce it to the same temperature as the English scale.

Unless this be done a discrepancy must always become apparent in the reduced readings of the two scales. For instance, in the case of a mountain barometer, by one of our leading makers, and now in my possession, I find 761.99^{mm} are made to correspond (following the authority of the tables) to 30 inches. If the temperature of the attached thermometer be 62° F., the respective readings reduced to the freezing point become 30 — 0.090 = 29.910 inches at the standard temperature, (62° F.,) 761.99 — 2.05 = 759.94^{mm} at the standard temperature 0° C., (32° F.) Turning to the tables for the comparison of the scales, we find that 29.910^{in} at 62° F. are equivalent to 759.70^{mm} at 0° C., instead of 759.94 as above. If the barometer was properly constructed we ought to have now 761.75^{mm}, as corresponding to 30 inches, and the figures

reduced to the freezing point would be 30 — 0.090 + 29.910 standard inches, 761.75 — 2.05 = 759.70 standard *mm*, a result which corresponds with the figures of the tables.

For particular purposes the case may be put briefly as follows: At the respective *standard temperatures* 1 inch = 25.39954^{mm} or 25.4^{mm} nearly. At 62° F., and therefore at any other temperature common to the two scales, 1 inch $= 25.4\ (1 - 30a)^{mm}$, where a equals the coefficient of dilatation of brass for 1° F. = 0.0000104344, 1 inch = $25.4^{mm} - 0.008 = 25.392^{mm}$. Therefore, at the *standard temperatures* 30 inches = $25.4^{mm} \times 30 = 762^{mm}$ as in the tables. At a *common temperature* 30 inches = $762.0^{mm} - 0.008 \times 30 = 761.760^{mm}$. In practice this is sufficiently near, but if greater accuracy be required, the following figures may be adopted as the respective equivalents of an inch and a millimetre at all *common temperatures*: 1 inch = 25.3916^{mm} and $1^{mm} = 0.0393831$ inches. The following tables are constructed on this basis:

TABLE I.

Inches.	*Millimetres.*	*Inches.*	*Millimetres.*	*Inches.*	*Millimetres*	*Inches.*	*Millimetres.*
32 =	812.5312	27 =	685.5732	10 =	253.9160	5 =	126.9580
31	787.1396	26	660.1816	9	228.5244	4	101.5664
30	761 7480	25	634.7900	8	203.1328	3	76.1748
29	736.3564	20	507.8320	7	177.7412	2	50.7832
28	710.9648	15	380.8740	6	152.3496	1	25.3916

TABLE II.

mm.	*Inches.*	*mm.*	*Inches.*	*mm.*	*Inches.*	*mm.*	*Inches.*
800 =	31.50648	100 =	3.93831	30 =	1.181493	5 =	0.1969155
700	27.56817	90	3.544479	20	0.787662	4	0.1575324
600	23.62986	80	3.150648	10	0.393831	3	0.1181493
500	19.69155	70	2.756817	9	0.3544479	2	0.0787662
400	15.75324	60	2.362986	8	0.3150648	1	0.0393831
300	11.81493	50	1.969155	7	0.2756817		
200	7.87662	40	1.575324	6	0.2362986		

The tables to which I have throughout referred are those published by the Smithsonian Institution, Washington, among their Miscellaneous Collections and under the able editorship of Professor A. Guyot. (Second edition, Washington, 1858.)

F. F. TUCKETT.

APPENDIX B.

The common method of calculating the annual means of the temperature and atmospheric pressure from the monthly means is not quite exact. I presented a paper on this subject to the Silesian Society for the Progress of the Country, ("Schlesische Gesellschaft für vaterländische Kultur,") of which I beg leave to give here an abstract.

The monthly means being the quotient of the sum of the daily means by the number of days in the month, it is clear that we obtain that sum by multiplying the given monthly mean by the corresponding number of days. This being done with all the months composing the year, the sum of these twelve products will be equal to the total sum of all the daily means in the year, which divided by 365 (or by 366 in a leap year) gives the true annual mean. The difference of the true mean and the common mean increases with the divergencies of the monthly means.

The ordinary mean temperature of Caracas would be, taking the numbers given in the foregoing table, 71°.707, while the true mean is 71°.711; the ordi-

nary mean barometric pressure from the same source is $26^{in}.962517$, the true mean $26^{in}.962515$; the first shows a difference of $+0°.004$, the second of 0.000002 inches.

It is easy to prove that this difference (Δ) for a common year is represented by the following equation:

$$4380\Delta = 7\ (m_1+m_3+m_5+m_7+m_8+m_{10}+m_{12})-29\ m_2-5\ (m_4+m_6+m_9+m_{11})$$

and for a leap year:

$$732\Delta = (m_1+m_3+m_5+m_7+m_8+m_{10}+m_{12})-(m_4+m_6+m_9+m_{11})-3\ m_2$$

where m_1 m_2 m_3, etc, are the monthly means corresponding to the first, second, third, etc., month.

Taking again the case of Caracas as an example, we find a difference for the thermometric means of $\frac{2.82}{732} = 0°.0038$ as stated above, and for the barometric means of $\frac{0.0016}{732} = 0.0000022$ as before.

AN ACCOUNT OF A CYCLONE, JANUARY 6 AND 7, 1867, ENCOUNTERED BY THE UNITED STATES STEAMER MONOCACY, WHILE ON HER PASSAGE FROM SIMON'S BAY TO MAURITIUS, IN THE INDIAN OCEAN.

By Nicholas Pike, United States Consul, Port Louis.

The United States steamer Monocacy, bound from Simon's bay, South Africa, towards Mauritius, met, during the passage to the last-mentioned port, one of those dreaded tornadoes or hurricanes that swept over the vast expanse of the South Indian ocean. Being myself on board of the Monocacy, and deeply interested in the science of the laws of storms, I succeeded, by careful observations of barometer and thermometer, by noticing the changes of wind and temperature, and the rising and setting of the storm wave, to ascertain pretty correctly the centre of the hurricane, and deduce all the aforesaid changes of wind and weather to the rules laid down by Messrs. Piddington and Redfield, in their admirable treatise on the law of storms; the officers of the vessel kindly supplying me with a copy of the log, which, if even not very correct, greatly aided me in tracing the cyclone home to its vortex.

As my object in writing this is not a description of the storm, but especially facts and dates, and arranging such in tables to prove the correctness of the theory of cyclones, I shall previously insert a short description of the tempest. The whole of our passage, since leaving Simon's bay, had been a succession of bad weather, and the few sunny days which we in reality had were both to officers and men a veritable blessing; sails were repaired, hammocks and bedding aired, clothes dried and mended, and the decks, for the first time quite dry, resounded in every direction with the joyous laughter of the crew, carelessly forgetting the past troubles, living only for the present, regardless for the future. But their joy was of short duration. On the evening of the 6th of January, the sky became gloomy, dark threatening clouds passed swiftly to the northward, the sea rose fast, and the vessel commenced to roll heavily; bedding and clothes were quickly taken below, and everything secured for the bad weather again. The night, from January 6 to 7, fully justified our anticipations; heavy blasts of wind, rain, and lightning, the rolling of the vessel, the cracking of her timbers, and the thundering noise of a wave breaking under the vessel's counter, made, I may safely say, even the oldest seamen on board uncomfortable, especially as the vessel being new, and her sea-worthiness to all, even to the captain, unknown, we had not that confidence in her which her gallant behavior afterwards during the

following gale inspired us all; sails were reduced, or partly so, by the aid of the storm, the flapping of the canvas, torn to ribbons by the rage of the tempest, the loud thunder, the occasional flashes of lightning, the rising of a tremendous wave, showing first its white foaming crest far off on the horizon, and then drawing nearer and nearer, till you might almost fancy it would instantly engulf us, but our gallant craft rose nobly to the crest of the surge. All this was a spectacle wild and fearful to behold, but in its very wildness grand and sublime. Then, I may say, the metal of our crew was tried, and the true sailors, both among officers and men, were found; but alas! how few, out of that great number! They worked hard, sending down masts and yards, repairing or bending the storm-sails, or standing at the pumps, knee-deep in water, that washed unceasingly over the decks. Daylight showed us at last the extent of the damages the vessel had sustained; the paddle-boxes, the roundhouses were smashed in and washed away, the rail forward was stove in, and the heavy one-inch iron plates were bent double, the ring-bolts to which the heavy pivot guns were secured started from the deck, and the guns threatened with each roll to break adrift from their lashings; a temporary lull in the gale gave us time to secure them, and repair damages a little. Everybody hoped for good weather, as the heavy rain which fell during four or five hours beat the sea down considerably, but on the evening of the 7th the storm commenced again. A red lurid light spread all over the sky, and shortly after the setting of the sun the ocean became furious once more. A tremendous sea breaking over the starboard bow swept everything before it, tearing away the gratings of the hatches, breaking the after sky-lights, and rushing down into the ward-room and cabin, floating and drenching everything and everybody. The tiller ropes having been carried away, the ship, paying off before the wind, became unmanageable; the guys of the smoke-stack having broken, it was feared that the heavy mass of iron would descend upon us, smashing everything; the ship then coming to again filled her decks with water, and leaning over to port, remained so long in that position that even the stoutest heart quailed, and anxiously counted the seconds till at last the ship rose gallantly again on the crest of the next wave; luckily the sea having stove in the lower ports, the immense quantity of water found a ready egress from her decks, and the vessel, lightened of her weight, rolled less heavily; new wheel-ropes were rove, and the storm having spent its fury abated greatly. In the morning a heavy shower of rain smoothed down the sea considerably, and a little before six o'clock the sun rose red and gloriously in the east, in a fair and cloudless sky. The danger passed, the heavy puffing and snorting of the powerful engine showed that the good ship was once more speeding onward, gracefully throwing the splashing, glittering spray from her bow back into the conquered ocean.

Taking a scientific view of huricanes and cyclones, and the management of vessels therein, it is clear that there are three ways of managing a ship in or at the approach of a cyclone: First, in order to avoid the same, (in case there is plenty of sea room,) the vessel should be hove to on the proper tack. Second, if a ship is caught inside of a storm disk, the only chances to be adopted are, running before the wind, or heaving the ship to, and the latter, when on account of the high or cross seas the safety of the ship is endangered, the only course left is to run before the wind in a tangent direction toward the inner storm disk, and then gradually to edge off to the outer limits of the cyclone; and lastly, by running on the outside of the wind's circle, and even profit by it. But the question is, how to know the approach of a cyclone, how to find the proper bearings of its centre. Considering then every cyclone as a great whirlwind, the direction of every wind as a rotary, of which the outer part is a common close-reefed topsail breeze, such as seamen do not care for, and by which no seaworthy ship is injured, but the violence of the wind increases with great rapidity as the centre is approached, till close or in it, when it becomes of a destructive fury, and even

if this centre should have a diameter of 50 or 60 miles, round which the storm is revolving, our first care must be to ascertain how this point or centre bears from us, in order to guide our future manœuvres. Now, as the Monocacy on the 5th of January was, according to her log, in latitude 32° 15′ south, and longitude 47° 45′ east, the wind marked as E.SE., the centre of every common wind would lay, according to proved and established rules of storms, to the E. by N. or E.NE. In the remarks on January 5th it is said, clouds accumulating, cloudy and damp, moderate breeze from SE. by E., sent up foretopmast; from 4 to 6, squally and damp, heavy swell from SE. by E., light winds; 6 p. m., a drizzling rain, but with all these clouds and dampness we find the state of the barometer as shown in the diagram, the lowest stand being 30.1; in the diagram stating the position of the ship and centre bearings, the storm disk with its hourly changing tangent angles is named a moderate gale; the outside circle of a hurricane, accompanied with a surrounding atmosphere slightly disturbed; the greatest signs of an approaching cyclone are the oscillations in barometer and sympiesometer, more especially a high barometer with gloomy threatening weather; in the track of the trades and monsoons this is almost always a sure sign of an approaching tempest.

Looking at the table we must naturally be surprised to see that, regardless of all these signs, the vessel was still kept on her course, that is to say between E.NE. and NE. by E. The question naturally arises, can the barometer assist us in forming an approximative estimation of the ship's distance from the centre? And on first consideration, it is evident that there are very great differences in the fall and rise of a barometer and sympiesometer, in various storms, though they may be all true cyclones. Consequently the variations of these instruments may very often mislead us; but the shortness of the time in which these changes happened, the number of barometers which underwent the same changes, was enough to make even the most careless seaman comprehend the danger and the close approximation of the destructive centre. But looking again at the barometer and sympiesometer stand of January 5th, we find that it ought to have been considered, first, the previous height of the barometer; second, the exact time for a given fall or rise; and third, the change of the observer's position, especially when running or steaming. The diagram here then shows the height and the hourly change of a barometer and sympiesometer, and the distance from the centre is worked out according to Mr. Piddington's rule. Certainly these calculations are only to be made approximatively, but coming so near to the truth that we may consider the result to be the true centre. Now, as in the Southern Indian ocean, the rate of travelling of a hurricane may be stated to be little more than nine or ten miles per hour, and especially in the meridian between Mauritius and Madagascar, the rate generally does not exceed eight miles per hour, it is evident that with even the little progress the Monocacy made against a head wind and sea, the course to the northward and eastward brought her without question nearer to the focus. The weather during the following days showed no material alteration; the same dark cloudy sky, the same height of barometer, slightly varying as by the ship's progress we neared the centre. The table shows the indications of barometer and sympiesometer for the 6th, 7th, and 8th, in her log-book. I find the oscillations of one barometer and the vibrations of an aneroid barometer very strongly marked; both are common signs during a cyclone. On January 7th, states the log, the water changed its appearance to a dark brown color, the sea was running furiously, and in various directions; the vessel was at that time under storm mainsail, double-reefed fore trysail, and storm fore topsail, the topsail yard and fore yard on deck, and fore and main topmasts housed; everything was secured about her decks, and the vessel kept under just enough steam to hold her own, but still heading to the northward and eastward. During the night from the 7th to the 8th the storm had reached its climax; it blew the storm staysail out of the bolt ropes, and the

ship having lost her starboard bulwarks, shipped a tremendous quantity of water, which flooded her decks; this and the tiller carrying away, her helm shifted thereby over to starboard, and made the vessel pay off before the wind; with the greatest difficulty a new tiller was shipped, and the vessel again was kept up to the eastward. In the storm chart it will be seen that the vessel, during this night, was nearest to the vortex. On the following day, the 8th, the storm having passed the vessel, no material danger threatened us longer; the barometer still kept unusually high, and the whole day the sky wore an unusually bright appearance; the air likewise was charged with a great amount of electricity; incessant thunder and lightning were the consequences. In the afternoon it was calm, but the sea still ran high, which made the vessel labor heavily; barometer at 30.14, the thermometer 74.5 Fahrenheit. At 6 p. m. a heavy rain smoothed the sea down, and the vessel, after having undergone the necessary repairs, steamed towards her destination.

But before I conclude this description I can hardly omit a word about the origin of cyclones. It appears to me that a simply flattened spiral stream of electric fluid generates above, and expanding in a broad disk, may amply account for the commencement of a cyclone. By its descending to the surface of the earth, and that likewise its onward motion, in such a direction as the law of force and gravity drives it, may simply account for its continuance, and the oppression and exhaustion of its force for its termination. The unequal motion is naturally the consequence of one side of the disk being more flattened, and causing the cyclone to advance more rapidly; the descent or settling down of the cyclones has in numerous cases been proved; the appearance of the vortexes of violent tornadoes within the body of great storms is not unfrequent or new.

A curious phenomenon was the brightness of the sky at sunset on the 7th of January. The whole horizon became suddenly suffused with a bright scarlet color; I do not remember ever it happening before, and even the very zenith and all the horizon round was affected by it. All these signs combined were strong proofs of a cyclone, and the management of the ship should have been acted upon accordingly. Commanders and officers of men-of-war should strictly consider the competence of junior officers before intrusting them with a watch, whether or not they are able to take charge of one, as courage and daring have during the late war elevated many a person to a position which is far above his experience. Courage and daring are in war two main virtues, and most desirable, but experience and cool judgment in peaceful times, and during the raging of a tempest, are the most wished-for qualities in an officer, whether in the merchant service or navy.

But still, looking calmly on the past dangers, I cannot omit to render, next to God, to the commander and to some of the officers and crew of the Monocacy my thanks for a safe delivery out of one of those terrible cyclones that occur in the South Indian ocean.

Table showing the hourly change of wind, the course steered, the height of barometer, thermometer and sympiesometer, and temperature of water during the cyclone.

Hour.	Wind.	Course.	Barometer.	Thermometer.	Sympiesometer.	Temperature.	Remarks.
1	SE. by E	East	30.2	72.5	0.026	74.3	
2	SE. ¾ E	East	30.1	72.6	0.027	74.3	Cloudy.
3	SE. ¾ E	East	30.1	72.6	0.027	74.8	Do.
4	SE	East	30.2	72.5	0.028	74.8	Rain.
5	SE. ½ S	E. ½ N	30.1	72.5	0.027	74.8	Do.
6	SE. ½ S	E. ½ N	30.1	72.5	0.026	74.8	Do.
7	SE. by S	E. by N	30.1	72.5	0.020	74.2	Cloudy.
8	SE. by S	E. by N	30.14	75.0	0.018	74.3	Do.
9	SSE. ½ E	E. by N	30.15	75.3	0.016	74.3	Do.
10	SSE. ½ E	E. ½ N	30.17	75.0	0.016	74.3	Do.
11	SSE. ½ E	E. ½ N	30.17	75.0	0.016	74.1	Do.
12	SSE	E. ½ N	30.15	75.0	0.015	74.3	Do.
1	S. by E	E. ½ N	30.15	75.0	0.015	74.3	Do.
2	S. by E	E. by N	30.14	75.0	0.015	74.3	Rainy.
3	S. by E	E. by N	30.14	75.0	0.015	74.3	Do.
4	South	E. by N	30.13	75.0	0.012	74.5	Do.
5	South	East	30.6	75.3	0.10	74.5	Do.
6	South	East	30.15	75.1	0.08	74.5	Strong gale.
7	S. ½ W	East	30.15	75.1	0.08	74.5	Do.
8	S. ½ W	East	30.15	75.2	0.08	74.12	Do.
9	S. by W	East	30.15	76.2	0.08	74.12	Do.
10	S. by W	East	30.20	76.2	0.07	74.12	Do.
11	S. by W	East	30.21	76.2	0.07	74.12	Do.
12	S. by W	East	30.21	76.2	0.07	75.0	Do.

The greatest height of barometer 30.21
The lowest stand of barometer 30.1
The lowest stand of sympiesometer 0.07

SOME OBSERVATIONS ON THE GREAT HURRICANE OF OCTOBER 29, 1867, AT TORTOLA, (OR PETER'S ISLAND,) ST. THOMAS, AND PART OF PORTO RICO.

By George A. Latimer.

What is usually called the great hurricane of 29th October, 1867, should, it seems to me, rather be called a tornado, or a number of tornadoes, almost joined and moving nearly together, for the following reasons: Hurricanes extend far and are wide; this occurrence on the 29th October was short in extent and narrow. It appears to have begun at Tortola, (Peter's island,) at 9 a. m., with wind at northeast, and lasted until 1.20 p. m., wind going all round the compass, the hardest being from northwest.

At St. Thomas it began at 10 a. m., with wind from northeast, and a heavy rain; at 11.15 a. m. calm until 12.15 p. m., when wind came furious from west, and blew until 2 p. m.; then a dead calm until 2.30 p. m., when the wind came with fury from the east, accompanied by a heavy rain and a white atmosphere. This, the second and most terrific part, lasted until 4.15 p. m., when it fell calm, and the night following was clear, with a bright sky. While the wind was blowing so hard from the east, the barometer fell 14 lines, and remained so for 30 minutes.

At east end of Porto Rico, say Fajardo, Naguabo, and Humacao, it began at 11 a m., with wind from northeast, shifting to southeast and south until 1.15 p. m., then calm until 2 p. m., when the wind came from northwest, and at 4 p. m. it entirely ceased, and the evening and night following were calm. During the violence of the wind, (but the hour is not given,) the sea rose in Fajardo and Humacao about four feet, overflowing the beaches and all the store yards for a very great distance.

At Loiza (going down the north side) it began at 4 p. m., with wind at north, shifting to northeast, and lasted until 10 p. m., when the wind abated, but it rained heavily all the night.

At the city of St. John's, (going down the north side,) it commenced at 4 p. m., with wind from north, and lasted until 10 p. m. Here it was not severe, and no damage done; neither was there any done further down the north side of the island, but there was a heavy rain, causing floods in the rivers, &c.

At Arroyo, on the south side, it began at 4 p. m., with wind from east, barometer 29.09; at 7 p. m. barometer at 29.15, and wind changed to south, and blew very hard until 9.30 p. m., when it was all over; and it does not appear to have gone further down the south side of Porto Rico.

Thus, the course of it seems to have been striking:

1. Tortola, (or Peter's island,) at 9 a. m., wind from northeast;

2. St. Thomas, 30 miles to leeward, at 10 a. m., wind northeast;

3. Porto Rico, east end, 28 miles to leeward, at 11 a. m., wind northeast; north side, Loisa, 20 miles to leeward, at 5 p. m., wind north; city of St. John's, 20 miles to leeward, at 4 p. m., wind north; south side, Arroyo, 64 miles to leeward, at 4 p. m., wind east, and not going further westward than St. John's on the north and Arroyo on the south side; so that it cut across Porto Rico from north-northeast to south-southwest in about one-third of its length, making great destruction in the trees on the mountains and in the tops of those on the plains and low hills, as is to be seen and traced throughout its whole course; and as the lower two-thirds of the island were not injured by the winds, only by heavy rains, it shows the tornado passed off to south-southwest, or disappeared upwards. That it did not extend further to the eastward is proved by the arrival of vessels at St. Thomas the next day without their having felt it; whereas, had it been a hurricane, from their position they should have felt it. So, also, a vessel bound into Arroyo, and another from Arroyo to Humacao, seeing the weather look threatening, stood to the south, and only had a strong northeast wind all night, going into their respective ports of destination the next morning, to find there had been a tornado passing over both places.

PRIZE QUESTIONS.

QUESTIONS PROPOSED FOR COMPETITION BY THE ROYAL DANISH SOCIETY OF SCIENCES, 1867.

Class of Natural History and Mathematics.—*Question of natural history.*—Although the lichens have been the object, in late years, of very profound researches, (especially on the part of MM. Tulasne, Nylander, Th. Fries, and Speerschneider,) there are still many points of great interest in their life and development, respecting which our knowledge remains very incomplete.

Although M. Tulasne had demonstrated in 1852 that all the lichens are furnished with a special organ, (spermagorie with the spermatiæ,) and his researches render it more than probable that this organ must serve for fecundation and correspond to the male reproductive organ, there has, thus far, been no observation made, nor experiment, which might establish conclusively that the organ in question fulfils that function. We have, moreover, recent observations (of MM. Hicks and Bary) which prove that there are certain species of colimaceæ which stand in generic relation to plants which have been heretofore considered as types of algæ, (Nostochaceæ, Chroococcaceæ;) but the true nature of that relation is still completely unknown. It results, lastly, from recent researches, that there are reproductive organs (apotheciæ) without a thallus, which appear to subsist as parasites on the thallus of other species. They have been classed as distinct species or genera in a family apart, (the pseudolichens,) or considered as champignons or special organs of the plants on which they live. The true nature of these organisms or organs is therefore still very enigmatical. The society proposes its gold medal as a recompense for the solution, in a satisfactory manner, of one or more of these three points.

Question of mathematics.—The potential may be reduced to a more general form, when the variable, μ, in the function $\Sigma\frac{\mu}{r}$, is considered as a function of $t-\frac{r}{a}$, t being a new variable and a a constant. As the potential thus generalized may receive applications much more extended, the society desires that, besides a recital of the principal propositions heretofore known in relation to this function, an investigation of the same function should be submitted to it under the form above indicated.

Class of History and Philosophy.—*Question of history and philology.*—How have the classical Latin authors been appreciated and how far have they been made use of by the grammarians of the time of the empire and by their schools? What influence was exerted by this appreciation and this use on the preservation or disappearance of literature, and how much of the literature of antiquity may be estimated to have remained in circulation or to have been accessible, about 500 years after Jesus Christ?

The answers to these questions may be written in Latin, French, English, German, Swedish, or Danish. The memoirs should not bear the name of the author, but a motto, and be accompanied by a sealed note distinguished by the same motto and enclosing the name, profession, and address, of the author. The members of the society who reside in Denmark will take no part in the competition. The recompense accorded for a satisfactory reply to one of the proposed questions, will be the gold medal of the society, of the value of 50 Danish ducats. The replies must be addressed, before the end of October, 1868, to the secretary of the society, Professor J. Japetus Sm. Steenstrup.

PONTIFICAL ACADEMY OF THE NUOVI LINCEI.—PROGRAMME FOR THE CARPI PRIZE.—ROME, JUNE 12, 1868.

The academy, with the view of conferring the annual prize founded by the generous testamentary provision of its late associate doctor, Pierre Carpi, proposes the development of the following theme:

To compare with one another the tides of the principal ports of all the Italian coasts, and to appreciate and explain their differences.

EXPLANATION.—Galileo had occupied himself with the flow and ebb of the sea.* But in his time, that is to say in 1616, neither the true doctrine of universal attraction nor the higher analysis was known; it was not possible, therefore, to indicate the principal causes of the phenomenon in question. Notwithstanding this, that illustrious Lincean sought,† two and a half centuries ago, to investigate the probable reasons which cause the flow and ebb of the sea to be more sensible in the Adriatic, and especially at Venice, than on the coasts of the Mediterranean. It thus appears that our subject was, in part, considered by the glorious reformer of the doctrines of Aristotle.

In its discussion the proposed theme should be well developed, yet all that does not strictly pertain to the question should be avoided, without, however, going so far as to suppress anything which may contribute to give clearness and force to the demonstrations. It will be of great service to the author to be acquainted with the researches respecting the tides already executed by physical geographers, such, for instance, as Humboldt, Whewell, Lubbock, Berghaus, Germar, Thomson, Maury, Dession, Chezallon, &c., and also by the modern geometers, Laplace, Delaunay, and others.

The author should have recourse to sources, either official or entirely worthy of credit, for the observations which have been made on the cotemporaneousness of tides, on their differences in point of time, and should indicate whence he has collected those observations. He should also state the intervals which separate high tide from the lunar culmination, and likewise its maximum, minimum, and mean ordinary or extraordinary height, at the syzygies and at the equinoxes, under the influence of certain winds and on occasion of considerable changes of atmospheric pressure, &c. All the physical or geographical circumstances which modify the usual course of the tides should be generally stated, and explanations furnished. Above all it is requisite to indicate the causes of the differences observed between the tides of the principal ports of all the coasts of Italy. Finally, it is recommended that the argument should be developed also in its relations to mathematical analysis, taking as a guide chiefly what has been published on this subject by the illustrious Laplace in his *Mécanique céleste.* But if the author finds that our theme does not, from its nature, permit the application of analysis, he should clearly set forth the difficulties which oppose themselves to the attempt.

Although in strictness the theme simply demands a scientific study and explanation of the tides in the principal ports of Italy, by reason that these offer a greater interest, yet the academy will receive with thankfulness, observations and researches on the tides at every other point of the Italian coasts, whether in the islands or on the continent.

CONDITIONS.—1. The memoirs on the proposed theme should be drawn up either in Italian, Latin, or French; no other language is admissible. 2. Each memoir will be preceded by an epigraph, which shall be repeated on the outside of a sealed envelope, containing the name and address of the author. 3. Only the envelope corresponding to the memoir which shall obtain the prize will be

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*A manuscript treatise on this physico-geographical phenomena may be found in the library of the Vatican; it contains a highly interesting autographic frontispiece of Galileo.

† Le opere di Galileo Galilei; t. I°, Florence, 1842, p. 498, and t. II°, Florence, 1843, p. 400.

opened. 4. If the authors who shall have obtained an honorable mention desire that the academy should publish their names, they must make a request to that effect within the four months following the day on which the prize shall have been decreed; at the end of that term the envelopes will be burned without being unsealed. 5. With the exception of its thirty members in ordinary, the academy invites the competition of all persons, whatsoever their nationality. 6. Each memoir, with its corresponding envelope, must be sent, free of postage, to the academy before the last day of October, 1869, the date at which the competition closes. 7. The prize will be awarded by the academy in the month of January, 1870, and will consist of a gold medal of the value of a thousand livres. 8. The successful memoir will be published whole, or in extracts, in the acts of the academy, and the author will receive fifty copies.

B. VIALE PRELA, *President.*
P. VOLPICELLI, *Secretary.*

ABBREVIATIONS USED IN ENGLAND IN 1867.

COMPILED BY W. DE LA RUE.

A.—Associate.
A. B.—Artium Baccalaureus. *Bachelor of Arts.*
Abp.—Archbishop.
A. C.—Anno Christi. *In the year of Christ.*
A. D.—Anno Domini. *In the year of our Lord.*
A. I. C. E., or A. Inst. C. E.—Associate of the Institution of Civil Engineers.
A. M.—Anno Mundi. *In the year of the world.*
A. M.—Artium Magister. *Master of Arts.*
A. M.—Ante Meridiem. *Forenoon.*
A. R. A.—Associate of the Royal Academy.
A. R. S. A.—Associate of the Royal Scottish Academy.
Bart., or Bt.—Baronet.
B. A.—Bachelor of Arts.
B. C.—Before Christ.
B. C. L.—Bachelor of Civil Law.
B. D.—Bachelor of Divinity.
B. L.—Bachelor of Law.
Bp.—Bishop.
B. Sc.—Bachelor of Science.
C., or Cent.—Centum. *A hundred;* or Chap.—Chapter.
Cam., or Cantab.—Cambridge.
C. B.—Companion of the Bath.
C. E.—Civil Engineer.
Coll. Reg. Chir.—Royal College of Surgeons.
Coll. Reg. Med.—Royal College of Physicians.
C. P. S.—Custos Privati Sigilli. *Keeper of the Privy Seal.*
Cr.—Creditor.
C. S.—Custos Sigilli. *Keeper of the Seal.*
Cwt.—Hundredweight.
D.—Five hundred.
d.—Denarius. *A penny.*
D. C. L.—Doctor of Civil Law.
D. D.—Doctor of Divinity.
D. G.—Dei Gratiâ *By the Grace of God.*
Do.—Ditto. *The same.*
Dr.—Doctor, or Debtor.
D. Sc.—Doctor of Science.
D. V.—Deo volente. *God willing.*
Dwt.—Pennyweight.
E. C. P.—Evangelii Christi Prædicator. *Preacher of the Gospel of Christ.*
e. g.—Exempli gratia. *For example.*
Eq., or Eques.—Knight.
Esq.—Esquire.
Ex.—Example.
Ex., or Exr.—Executor.

F. C. P.—Fellow of the College of Preceptors.
F. C. P. S.—Fellow of the Cambridge Philosophical Society.
F. C. S.—Fellow of the Chemical Society.
F. D.—Fidei Defensor. *Defender of the Faith.*
F. G. S.—Fellow of the Geological Society.
F. H. S.—Fellow of the Horticultural Society.
F. I. A.—Fellow of the Institute of Actuaries.
F. L. S.—Fellow of the Linnæan Society.
F. R. A. S., or F. R. Astron. S.—Fellow of the Royal Astronomical Society.
F. R. B. S.—Fellow of the Royal Botanic Society.
F. R. C. S.—Fellow of the Royal College of Surgeons,
F. R. I. B. A.—Fellow of the Royal Institute of British Architects.
F. R. S.—Fellow of the Royal Society.
F. R. S. E.—Fellow of the Royal Society of Edinburgh.
F. R. C. P—Fellow of the Royal College of Physicians.
F. R. G. S.—Fellow of the Royal Geographical Society.
F. S. A.—Fellow of the Society of Antiquaries.
F. S. S.—Fellow of the Statistical Society.
F. Z. S.—Fellow of the Zoological Society.
G. C. B.—Knight Grand Cross of the Bath.
H. E. I. C. S—The Honorable the East India Company's Service.
Hon.—Honorary, Honorable.
Hon. Mem.—Honorary Member.
H. M. S.—Her Majesty's ship.
H. M. S. S.—Her Majesty's steam ship.
H. R. H.—His or Her Royal Highness.
Ib., or Ibid.—Ibidem. *In the same place.*
Id.—Idem. *The same.*
i. e.—Id est. *That is.*
I. C. S.—Indian Civil Service.
I. H. S.—Iesus Hominum Salvator. *Jesus, the Saviour of mankind.*
I. H. + S.—In hac cruce salus. *Safety in this Cross.*
I. P. D.—In præsentiâ Dominorum. *In presence of the Lords.*
J. P.—Justice of the Peace.
K. B.—Knight of the Bath.
K. C.—Knight of the Crescent.
K. C. B.—Knight Commander of the Bath.
K. C. G.—Knight Commander of the Guelphs [of Hanover.]
K. G.—Knight of the Garter.
K. G. C.—Knight Grand Cross.
K. H.—Knight [of the order of the Guelphs] of Hanover.
K. P.—Knight of St. Patrick.
K. T.—Knight of the Thistle.
Kt., or Knt.—Knight.
L., or Lib.—Libra, *a pound;* or Liber, *a book.*
L. C. J.—Lord Chief Justice.
L. D.—Lady Day.
Ldp.—Lordship.
LL. B.—Legum Baccalaureus. *Bachelor of Laws.*
LL. D.—Legum Doctor. *Doctor of Laws.*
L. S.—Locus sigilli. *The place of the seal.*
M.—Mille. *A thousand.*
M. A.—Master of Arts.
M. B., (Latin,) or B. M., (English.)—Bachelor of Medicine.
M. B. M. S.—Member of the British Meteorological Society.
M. C.—Member of Congress.

M. D.—Medicinæ Doctor. *Doctor of Medicine.*
Mem. Corr. or Corresp.—Corresponding Member.
M. I. C. E., or M. Inst. C. E.—Member of the Institution of Civil Engineers.
M. L. A.—Member of the Legislative Assembly.
M. L. C.—Member of the Legislative Council.
M. P.—Member of Parliament.
M. R. A. S., or M. R. Asiat. S.—Member of the Royal Asiatic Society.
M. R. I A.—Member of the Royal Irish Academy.
M. R. S. L.—Member of the Royal Society of Literature.
M. S—Memoriæ Sacrum. *Sacred to the memory.*
MS.—Manuscript. MSS.—Manuscripts.
Mus. D—Doctor of Music.
M. W. S.—Member of the Wernerian Society.
N. B.—Nota bene. *Mark well.*
M. R I.—Member of the Royal Institution.
Nem. con., or Nem. diss.—Nemine contradicente, or Nemine dissentiente. *Without opposition, unanimously.*
No.—Number.
N. P.—Notary Public.
N. S.—New Style.
Oxon.—Oxford.
Oz.—Ounce.
P., or Pres.—President.
Parl.—Parliament.
P. C.—Privy Councillor.
Ph. D.—Doctor of Philosophy.
P. M.—Post meridem. *Afternoon.*
P. S.—Postscript.
Q. C.—Queen's Counsel.
q. d.—Quasi dicat. *As if he should say.*
q. d.—Quasi dictum. *As if it were said.*
Q. E. D.—Quod erat demonstrandum. *Which was to be demonstrated.*
Q. E. F.—Quod erat faciendum. *Which was to be done.*
Q. S.—Quantum sufficit. *A sufficient quantity.*
Q. V.—Quod vide. *Which see.*
Rp.—Recipe. *Take.*
R. I. A.—Royal Irish Academy.
R. A.—Royal Academician.
R. A.—Royal Artillery.
R. E.—Royal Engineers.
R. H. A.—Royal Hibernian Academy.
Reg. Prof.—Regius Professor.
Rev.—Reverend.
R. M.—Royal Marines.
R. N.—Royal Navy
Rt. Hon.—Right Honorable.
Rt. Wpful.—Right Worshipful.
Sc., or Soc.—Fellow.
S. S. C.—Solicitor of the Supreme Court.
S. T. P—Sacro-Sanctæ Theologiæ Professor. *Professor of Divinity.*
Ult.—Ultimo. *Last month.*
T. D.—Theologiæ Doctor. *Doctor of Theology.*
Trust. Brit. Mus.—Trustee of the British Museum.
V. D. M.—Verbi Dei Minister. *Minister of God's word.*
V. P.—Vice-President.
W. S.—Writer to the Signet.

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